2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

DEPARTMENT OF MODERN INDIAN LANGUAGES AND LITERARY STUDIES
UNIVERSITY OF DELHI
DELHI-110007

No. FA / MILLS / 2018/ 4537(ii) Dated: 27.08.2018

TO WHOMSOEVER IT MAY CONCERN

Certified that, **Dr./Mr./Ms.** S. Vivekananthan of Sri Venkateswara College, attended the Committee of Courses meeting for Undergraduate Course Tamil language, which was held in the Department of Modern Indian Languages and Literary Studies, University of Delhi, on 27.08.2018.

G. Rajagopal
Head of the Department

अध्यक्ष / Head
आधुनिक भारतीय भाषा एवं साहित्यिक अध्ययन विभाग
Department of Modern Indian Languages & Literary Studies
दिल्ली विश्वविद्यालय / University of Delhi
दिल्ली-110007 / Delhi-110007

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

-------- Forwarded message ---------
om: **head mills** <millsduhead@gmail.com>
ate: Thu, Aug 16, 2018 at 10:38 AM
ubject: Under Graduate Courses Committee Meeting
: Sharmistha Sen <sharmisthasenn@yahoo.co.in>, munshi younus <younus_munshi@yahoo.co.in>, antara chaudhuri <chaudhuri.antara@rediffmail.com>, Debashish Banerjee debashish.banerjee@motherdairy.com>, Sivalingam Vivekananthan <drsviveka@gmail.com>, Seenivasan S <svc.seenivasan.delhi@gmail.com>, Elchuri Muralidhara Rao elchurimuralidhararao@gmail.com>, Prem Ananthan <kpremananthan@gmail.com>, Uma Devi <umadchitra@gmail.com>, Govindaswamy Rajagopal <grajagopaldu@gmail.com>, Venkata amaiah G <gvramaiah@gmail.com>, Narayanappa V <narayanappav@gmail.com>, chak amitava <amitavaz@yahoo.com>, S Manickavasagam <dr.mv1956@gmail.com>, sivappiriya usha sivamatshi@yahoo.co.in>, Mitali Barman <mitalibarman@gmail.com>, ratnottama das <ratnottama@yahoo.com>, dr.rajendra mehta <darvesh18@yahoo.com>, ravi prakash tekchandani avitekchandani@gmail.com>, <vishubellani@gmail.com>, Sreemati Di <itisreebeng@yahoo.com>, Prakash Pattnaik <prakash5385@yahoo.com>

ear Colleagues,
reetings to all. Please attend the UG Courses Committee meeting (related to preparing question papers for UG Programmes) scheduled on **Monday, 27th ug. 2018 at 11:30 a.m**. in the Seminar Hall, Tutorial Building, University of Delhi.

Vith regards,
. Rajagopal
Iead, Dept. of Modern Indian Languages

Letter for external examinership

varnika bhatia <varnikabhatia@yahoo.com>
Thu 11/8/2018 6:27 AM
To: gokhale_20@hotmail.com <gokhale_20@hotmail.com>

Dear Examiner

As Superintendent, Practical Examinations, Deen Dayal Upadhyaya College and in communication by the university I am pleased to invite you as external examiner to conduct the practical examination at our college as per the schedule below. A duly signed hardcopy of the same letter is dispatched at your address.

S.No.	Course/ Semester	Paper	Date	Time	Lab	Batch
1.	B.Sc. (H) Botany/ V-Semester	Reproductive Biology of Angiosperms	19.11.18	09:30 am-12:30 pm	II	I & II

I would appreciate a word of confirmation from your side by a returning mail.

Looking forward to see you

Thanks and kind regards
Dr. Varnika Bhatia
TIC, Botany Deptt.
Deen Dayal Upadhyaya College
University of Delhi, Delhi

Appointment as External Examiner for Practical Examination

deshbandhu college <dbcbotany@gmail.com>

Fri 4/19/2019 6:31 PM

To: gokhale_20@hotmail.com <gokhale_20@hotmail.com>

Dr. Pooja Gokhle Sinha
Department of Botany
Sri Venkateswara College
University of Delhi

Dear Madam,
This is to inform you that the practical examination for which you have been appointed as an External examiner by the University of Delhi will be held in the Department of Botany, Deshbandhu College as per the detail below:

Course/Class: B.Sc. (Hons.) Botany (Semester-IV) Practical Examination
Paper: Ecology (UPC- 32161402)
Date: **0**3-05-2019 (Friday)
Time: Morning (9:30 AM to 12:30 PM) group-I
Evening (01 PM to 04 PM) group-II

Thanking you

With regards
Dr. Rajender Kumar
(Teacher-in-Charge)
Department of Botany
Deshbandhu College
University of Delhi
Kalkaji, New Delhi- 19
Email: rkumar12@db.du.ac.in
Ph. 9958598104

/

Ref. No.: CD/Ex/038/19
Date: 15/03/2019

To

Dr. Pooja Bansal (SBSC) (Convener)
Examiner Code-19MBCPA5A

Subject: Request for setting of question papers by the Board of Examiners (paper setters) for the forthcoming Undergraduate Examinations;

Examinations held in the month of : Apr./May.2019

i) Annual Examination

Sir/Madam,

1. With reference to the above cited subject matter, I would like to take this opportunity to convey the decision of the University for setting of question papers by a Board of Examiners for the forthcoming Undergraduate Examinations in accordance with the Executive Council Resolution No. 05 dated 01-05-2013 which reads as under:-

   "Examination and evaluation / revaluation work be mandatory for all Colleges and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course."

2. The Board of Examiners, consisted of the following teachers is constituted, where you will act as the Convener/Examiner :-

1. Examiner	:	**Dr. Pooja Bansal (SBSC) (Convener)**
2. Examiner	:	**Dr. Neha Singhal (Venkateshwara)**
3. Examiner	:	**Dr. Shweta Kalra(STAC)**

3. This Board of Examiners would be responsible for setting of question papers as per following details:-

a) Name of course : **B.Com(P) Part-II**

b) Scheme/Mode of Examinations*:- **Annual**

c) Name of the Paper: **Business Statistics**

d) UPC/Subject Code: **B-101**

e) Medium of setting the Question paper : English / English & Hindi Language

* (Semester, FYUP, CBCS or Annual)

4. It would be the responsibility of the Convener to ensure that the paper is set as per the syllabus and the scheme of examination. The syllabus and the schemes of examination is available on the University of Delhi website OR may be obtained from the Department Concerned.

5. The four schemes of Undergraduate examinations viz. ***CBCS mode, three year semester mode, erstwhile FYUP Semester mode and Annual mode are running simultaneously,*** therefore the board of examiners are required to ensure to set question papers for the mode/scheme for which paper setting is to be done as per Subject Code / Unique Paper Code alongwith relevant course content / syllabus, scheme of examinations, number of question papers required etc.

. The board of examiners shall ensure the compline of relevant guidelines for P.W.D. category candidates, wherever applicable. Para XV of the notification dated 28-01-2014 in this regard is reproduced below:-

"Alternative objective questions in lieu of descriptive questions should be provided for Hearing-Impaired persons, in addition to the existing policy of giving alternative questions in lieu of questions requiring visual inputs for persons with Visual Impairment."

Department of Commerce

University of Delhi

Delhi-110007

B.Com (P)Annual Part II Examination May/June 2019

Paper Setter

Paper-VI-A Business Statistics

(3Q.P/2hr/37Mks.)

1. **Dr. Pooja Bansal (SBSC) (Convener)(Examiner Code-19MBCPA5A)**
   Ph:- **9311437085**

2. **Dr. Neha Singhal (Venkateshwara) ()(Examiner Code-19MBCPA5B)**
   Ph:- **9871724799**

3. **Dr. Shweta Kalra (STAC)(Examiner Code-19MBCPA5C)**
   Ph:- **9953308983**

BUSINESS STATISTICS

SET-A

PART – B

1. a) Which average is based on all the observations? (1)
   b) If mean is 79 and variance is 64. Calculate the value of Coefficient of Variance (C.V)? ~~(4)~~ 3.
   c) If the arithmetic mean and geometric mean of two variables are 10 and 8 respectively, find the values. ~~(4)~~ 3.
   d) If the two regression coefficient are 0.8 and 0.6, what would be the coefficient of correlation? ~~(4)~~ 3
2. a) From the following information, calculate the value of N, the number of pair of observations:
   r= 0.8, $\sum xy = 60$, $\sigma_y = 2.5$ and $\sum x^2 = 90$, where X and Y are the deviations from the respective means. ~~(4)~~ 3
   b) From the following data, find:
      i. the two regression equations.
      ii. The most likely marks in Statistics when the marks in Economics and Statistics.

Marks in Economics	25	28	35	32	31	36	29	38	34	32
Marks in Statistics	43	46	49	41	36	32	31	30	33	39

~~(8)~~ 6

OR

a) The mean of marks in Statistics of 100 students in a class was 72. The mean of marks of boys was 75, while their number was 70. Find out the mean of marks of girls in the class. ~~(4)~~ 3

b) calculate the coefficient of correlation from the following data and comment. ~~(8)~~ 6

Daily wages :	100	101	102	102	100	99	97	98	96	95
Cost of living:	23	22	24	17	19	20	18	94	90	91

3. a) State two major difference between correlation and regression analysis. ~~(4)~~ 2
   b) For the data given below, find the missing frequency if the arithmetic mean is Rs 28. Also find the median of the series.

Loss per shop (Rs) :	0-10	10-20	20-30	30-40	40-50	50-60
Frequency:	12	18	27	-	17	6

~~(8)~~ 6

OR

a) Distinguish between negative and positive correlation. ~~(4)~~

b) A worker in the city of Patna earns Rs 750 per month. The cost of living index for the month of January, 2018 is 160. Using the following data find out the amount that he spend on (1) Food and (2) Rent, if it presumed that he spends all his income on the following heads only:

Group	Expenditure	Group Index

37

BUSINESS STATISTICS

SET-B

PART B

1. a) An economy grows at the rate of 2% in the first year, 2.5% in the second year, 3% in the third year, 4% in the fourth year and 10% in the fifth year. What is the compound rate of growth of the economy for this five year period? ~~(2)~~ 1

   b) If two regession coefficient are 0.8 and 1.2, what would be the value of coefficient of correlation? ~~(4)~~ 3

   c) Find the value of third quartile, if the value of first quartile and quartile deviation are 90 and 20 respectively. ~~(4)~~ 3

   d) If co-variance between X and Y variables is 10 and the variances of X and Y are respectively 16 and 9, find the coefficient of correlation. ~~(4)~~ 3

2. a) What are the various mathematical properties of Standard Deviation? ~~(4)~~

   b) Find the calculations, find the class limits of all the classes of the continuous data given below and find the values of mean, mode and median. ~~(8)~~ 6

Mid-point of classes	Frequency
1-5	7
6-10	10
11-15	16
16-20	30
21-25	24
26-30	17
31-35	10
36-40	5
41-45	1

OR

a) The mean annual salaries paid to all employees of a company was Rs 500. The mean annual salaries paid to male and female employees were Rs 520 and Rs 420 respectively. Determine the percentage of males and females employed in the company. 3 ~~(4)~~

(b) Runs scored by Batsman A and Batsman B in last 10 matches are given below: ~~(8)~~ 6

Batsman A	Batsman B
44	48
80	75
76	54
48	60
52	63
72	69

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

Appointment as examiner by B.Sc.(H) Physics/B.Sc. PS paper - Message - Mail

Reply   Reply all   Forward   Archive   Delete   Set flag   ...

----- Forwarded message -----
From: "Physics Dept., Delhi University" <head.physics.du@gmail.com>
To: "Neetu Aggarwal" <neetu2803@gmail.com>, "gsaxena2006@yahoo.co.in" <gsaxena2006@yahoo.co.in>, "jha.sampurna@gmail.com" <jha.sampurna@gmail.com>, "somorendro singh" <somoren71@gmail.com>, "Somorendro Singh" <sssingh@physics.du.ac.in>
Sent: Mon, 25 Feb 2019 at 16:19
Subject: Appointment as examiner by B.Sc.(H) Physics/B.Sc. PS paper

Dear Colleagues,

You have been appointed as Convener/Examiner of a paper of II/IV/VI Semester of B.Sc. (H) Physics/B.Sc. PS whose details are contained in the attachment. The deadline for submitting the question paper sets is **March 09, 2019.**

It may be noted that as per the University ordinances, it is mandatory for a teacher to perform the assigned examination duty. It has been observed that some teachers decline the examination duty at the last moment without giving any serious reason, which undermines the examination process. In case you are unable to perform the assigned duty for some pressing reason, kindly write to the HOD latest by Feb. 27, 2019 giving reasons, with relevant documents.

Yours sincerely,

Head

Department of Physics & Astrophysics

Type here to search   ENG   14:46 09-04-2021

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

Date: 27th February, 2019

To

Dr. P. JAYRAJ
The Convener/ Examiner,
Department of ZOOLOGY
Sri Venkateswara College
University of Delhi, Delhi-21

Subject: **Request for setting of question papers by the Board of Examiners (paper setters) for forthcoming Undergraduate Three Year Semester- II / IV / VI Examinations, May / June – 2019 (CBCS & TYUP) for the Academic Year 2018-19 (Courses Committee Ref. No. SVC/BS/Th.Exam /May-2019/1 dt. 26th February, 2019) – Regarding.**

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set-in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

1.	Examiner	:	Dr. Kalyan Krishna (Convener)
2.	Examiner	:	Dr. P. Jayraj
3.	Examiner	:	—
4.	Examiner (If any)	:	—

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

From: **Department of Commerce Delhi University** <headoffice.commerce@gmail.com>
Date: Thu, 31 Oct, 2019, 11:52 AM
Subject: Details of External Examiner
To: <arpita@svc.ac.in>, sangeeta dodrajka <sangeetasggs@gmail.com>, <sggscc@rediffmail.com>

Dear Sir/Madam

The External Exam for the paper titled " Financial Accounting" of Semester I of B.Com under CBCS scheme will be held in the colleges.

Details of External Examiner

SGGSSC	Arpita Kaul	Venkateshwara college	arpita@svc.ac.in	9873609207

Head Office,
Department of Commerce,
Delhi school of Economics,
University of Delhi

From: **Shaheed Bhagat Singh College** <sbscprincipal@gmail.com>
Date: Fri, 15 Nov, 2019, 2:25 PM
Subject: Re: Appointment as External Examiner to conduct Practical Examination in the College
To: Arpita Kaul <arpita@svc.ac.in>

No. SBSC/ **Date: 13.11.2019**

Dr. Arpita Kaul
Sri Venkateswara College
Dhaula Kuan Enclave-I,
Dhaula Kuan
Delhi-110021

Dear Madam,

I am pleased to informed you that you have been appointed as External Examiner to conduct the practical examination of B.Com. (Prog.) on paper Tally to be held on 22nd November, 2019 in the College.

I request you to make it convenient to be present in the College for the conduct of practical examination as aforesaid on the above date and time.

Warm regards

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

(Dr. Anil Sardana)
Principal (Offg.)

On Thu, Nov 14, 2019 at 4:27 PM Arpita Kaul <arpita@svc.ac.in> wrote:

> Kindly change its Dr. Arpita Kaul
>
> On Thu, 14 Nov, 2019, 4:14 PM Shaheed Bhagat Singh College, <sbscprincipal@gmail.com> wrote:
>
>> Dear Madam,
>>
>> Please find enclosed herewith an attachment file for your kind information.
>>
>> (Dr. Anil Sardana)
>> Acting Principal

No.__________________
Date: 05/02/2019

To

Dr. Seema Gupta (RLA, 9891664133)
The Convener/Examiner,
____
____

Subject: Request for setting of question papers by the Board of Examiners (paper setters) for the forthcoming Undergraduate Examinations;

Examinations held in the month of : **May/June**___________.
Nov./Dec.___________.

i) CBCS Semester
ii) Erstwhile FYUP
iii) Semester Examination
iv) Annual Examination

Sir/Madam,

1. With reference to the above cited subject matter, I would like to take this opportunity to convey the decision of the University for setting of question papers by a Board of Examiners for the forthcoming Under-graduate Examinations in accordance with the Executive Council Resolution No. 05 dated 01-05-2013 which reads as under:-

   "Examination and evaluation / revaluation work be mandatory for all Colleges and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course."

2. The Board of Examiners, consisted of the following teachers is constituted, where you will act as the Convener/Examiner :-

1. Examiner : **Dr. Seema Gupta (RLA, 9891664133)** (Convener)
2. Examiner : **Dr. Veena Budhiraja (SVC, 9818970981)**
3. Examiner : **Dr. Priyanka Aggarwal (Hindu, 9810289803)**
4. Examiner : _______________
   (If any)

3. This Board of Examiners would be responsible for setting of question papers as per following details:-

a) **Name of course : B.Sc. (H) Statistics**

b) **Scheme/Mode of Examinations *:- SEMESTER**

c) **Name of the Paper: Econometrics**

d) **UPC/Subject Code: 237603**

e) **Medium of setting the Question paper : English /** English & Hindi Language

*** (Semester,** FYUP, CBCS or Annual**)**

4. It would be the responsibility of the Convener to ensure that the paper is set as per the syllabus and the scheme of examination. The syllabus and the schemes of examination is available on the University of Delhi website OR may be obtained from the Department Concerned.

5. The four schemes of Undergraduate examinations viz. ***CBCS mode, three year semester mode, erstwhile FYUP Semester mode and Annual mode are running simultaneously,*** therefore the board of examiners are required to ensure to set question papers for the mode/scheme for which paper setting is to be done as per Subject Code / Unique Paper Code alongwith relevant course content / syllabus, scheme of examinations, number of question papers required etc.

6. **The board of examiners shall ensure the compline of relevant guidelines for P.W.D. category candidates, wherever applicable. Para XV of the notification dated 28-01-2014 in this regard is reproduced below:-**

"Alternative objective questions in lieu of descriptive questions should be provided for Hearing-Impaired persons, in addition to the existing policy of giving alternative questions in lieu of questions requiring visual inputs for persons with Visual Impairment."

7. The Board of examiners shall be required to prepare and submit the sets of Question Papers to the University in the following manner:-

1) For Honours Courses	**:**	**02 (two) sets of Question Papers**
2) For Porgramme Courses	:	04 (four) sets of Question Papers
i) For B.A. (Prog.) Discipline Course – I/II	:	04 (four) sets of Question Papers
ii) For B.A. (Prog.) Language Courses	:	03 (three) sets of Question Papers

There should not be any preference of any particular set. The sets should be numbered as A, B, C & D (as the case may be). Each page of such set of question paper is required to be certified by the Board of Examiners at an appropriate place as mark of authenticity, **but personal details should not be mentioned on the question paper such as Name of Deptt./College of Paper Setter, telephone number, address etc.**

8. While undertaking this exercise, you are required to take into consideration the following instructions ;

(i) When a teacher is acting a part of the Board of Examiners, it should be ensured that no near relations (wife, husband, son, daughter, brother, sister, nephew, niece, sister-in-law or daughter-in-law, brother-in-law etc.) of the teacher is a candidate for the examinations under reference. A certificate is required to be signed by all concerned for this purpose. A copy of the certificate to be filled in by the members of the Board is enclosed as Appendix-III to this letter.

(ii) Any two sets of question papers should not have questions common in any of the papers. This means, there should not be any repetition of questions in the sets.

(iii) Utmost care and attention would be required while setting of question papers by the Board of Examiners with special reference to the course content/syllabus, scheme of examinations etc. The convener of the Board of Examiners should ensure such matters.

(iv) **The question papers set by a Board of Examiners must be moderated by the Moderation Committee at the department level.**

(v) Following technical specifications should be strictly adhere to while setting the question papers:

(a)	Font (in English)	-	Times New Roman
(b)	Font (in Hindi)	-	unicode / kruti dev
(c)	Font size	-	12
(d)	Space	-	Single Space
(e)	Paper size	-	Standard A4 size
(f)	Printing	-	On one side of the page
(g)	Certification/ Authentication	-	On the back of each page

(vi) A standard format for the first page of question paper is enclosed for ready reference as Appendix-I. However, instructions to the examinee relating to the structure of the question paper has to be specified at the time of setting of question papers by the Board of Examiners based on the syllabus and scheme of examination prescribed for the subject / paper like use of calculator, graph paper, log tables etc.

(vii) Utmost care should be given to ensure that name and identity of the Board of Examiners are not disclosed as it is strictly confidential to facilitate free & fair conduct of examination.

(viii) Translation is required to be carried out wherever needed. Each set of question paper, either in English or bilingual (English and Hindi) is to be packed in a separate sealed envelope alongwith a soft copy of the entire content of that corresponding set of Question Paper in Microsoft Word Format in the form of a CD. **Please note that hand written scanned copy of the question papers will not be accepted under any circumstances.**

(ix) There will be separate envelopes - for each set of question paper and it's CD. These envelopes should be signed and sealed separately and put inside a larger envelope and signed and sealed again by the Board of Examiners. The envelopes must be superscribed with the following details :

(a) Name of the Department
(b) Name of the Course
(c) Name of the Paper
(d) Scheme / Mode of Examinations
(e) Unique Paper Code /Subject Code

Such sealed packet should be handed over to the Head of the Department by the convener of the Board of Examiners immediately on completion of the exercise. The Board of Examiners would be entirely responsible for this exercise.

9. You would be required to submit the remuneration bill for the members of the Board of Examiners to the Head of Department. Necessary proforma for settlement of claim/settlement of advance alongwith guidelines of remuneration payable to the teachers in this regard is enclosed herewith for appropriate usage Appendix-II. However, conveyance charges for maximum 03 visits would be allowed to the Examiner / convener per paper.

10. Matters relating to South Delhi Campus should be taken up with the Examination Branch (South Delhi Campus) as such matters are separately dealt by the Examination Office of the South Delhi Campus.

11. **The Question paper/s must reach in the Examination Branch within 02 (two) weeks time from the date of issue of this letter.**

12. It will be highly appreciated if you kindly go through the entire contents of this letter and ensure that the procedure mentioned overleaf and above is scrupulously adhered to.

13. List of papers for which question papers have to be set, schedule of remuneration for such work alongwith various proforma / envelope etc. as mentioned in the body of the letter is enclosed for appropriate usage.

Yours faithfully,

(Head of the Department)

Encl.: As above

Copy to:

1. **Dr. Veena Budhiraja (SVC, 9818970981)**, Examiner I
2. **Dr. Priyanka Aggarwal (Hindu, 9810289803)** , Examiner II
3. ________________________, Examiner IV (if any)

Appendix-I

Format of the First page of a Model Question Paper in A4 size page

Unique Paper Code	**:**	**237603**
Name of the Paper	**:**	**Econometrics**
Name of the Course	**:**	**B.Sc. (H) Statistics**
Semester	**:**	**VI**
Duration	**:**	**3 hours**
Maximum Marks	**:**	**75 Marks**

Instructions for Candidates

UNIVERSITY OF DELHI

EXAMINATION – I / II

CHECK-LIST FOR CONVENER

S. No.	Type of Item	Quantity	Remarks Yes / No
1.	Letter of Appointment of Convener from the HOD	01	
2.	Copy of Undertaking of the examiners / paper setters to be submitted to the Head of the Department (Appendix-I) .	04	Yes
3.	Format of First Page of Question Paper for essential details (Appendix-II).	03	Yes
4.	Remuneration schedule alongwith remuneration claim form for examiners / paper setters (Appendix-III)	03	Yes
5.	Envelops along with proper superscription of details of Unique Paper Code etc. for each set of question paper to be set (a & b as the case may be) size of [10”x12”] .	02	Yes
6.	CD covers along with CD’s for each paper. CD cover should mention Set-A & Set-B along with details of Unique Paper Code etc.	02	Yes
7.	Envelope along with proper superscription of details of Unique Paper Code etc. in which all the set of the question papers is to be put by the convener and sent to the Head of the Department confidentially. [12”x16”]	01	Yes
8.	Envelope for enclosing remuneration claim bills	02	Yes

Annexure-II

University of Delhi

(To be filled up by the Head of the Department and returned to the Examination Office within 10 days of the receipt of the latter)

*I have not found any incompleteness (such as any missing papers etc.) or any inaccuracy in the details of papers to be set by the Department as provided by the Examination Office of the University in Annexure I.

OR

*I have found the following discrepancies in the details provided by the Examination Office of the University in Annexure - I. Kindly make the necessary corrections in the details of the papers to be set by the Department which is as follows. (Attach extra sheets, if necessary)

*Strike out whichever is not applicable

Head of the Department

Department of ____________

____

OSD - Examinations

--------- Forwarded message ---------
rom: **Seenivasan S** <svc.seenivasan.delhi@gmail.com>
ate: Fri, Sep 14, 2018 at 9:43 PM
ubject: Re: Tamil UGCC Meeting
o: head mills <millsduhead@gmail.com>
c: Prem பிரேம் <kpremananthan@gmail.com>, Uma Devi <umadchitra@gmail.com>, Govindaswami Rajagopal <grajagopaldu@gmail.com>, dr.mv1956 <dr.mv1956@gmail.com>, sivamatshi@yahoo.co.in>, Sivalingam Vivekananthan <drsviveka@gmail.com>

will attend the meeting.

n Thu, Sep 13, 2018 at 1:52 PM head mills <millsduhead@gmail.com> wrote:

Dear Colleagues,

Please attend the **UG Courses Committee meeting for Tamil** (related to preparing question papers for UG Programmes) scheduled on **Monday, 17th September 2018 at 11:30 a.m**. in the Seminar Hall, Tutorial Building, University of Delhi.

Pl see the attachment.

With regards,
G. Rajagopal
Head, Dept. of Modern Indian Languages
and Literary Studies, University of Delhi,
Delhi-110007

No.Maths/2018/PS/09
Date: 04.10.2018

Sir/Madam,

1. You are appointed as a Convener/Examiner for setting of question papers as per following details:-

Convener	Examiner	Examiner
Swarn Singh **Sri Venketswara College** **9818627285**	**Ritu Kathuria** **MNC** **9818002596**	**Sucheta Nayak** **LSR** **9990412080**

2. The Board of Examiners will set question paper for the **CBCS (B.Sc. (H) Mathematics** for the subject with the following details:

CBCS B.Sc. (Hons.) Mathematics **SEMESTER V**

Unique Paper Code	Paper Name
32357501	**DSE-I Numerical methods**

- Examinations to be held in the month of : November /December 2018
- Medium of setting the Question paper : English
- Submit Question paper in the department by **October 15, 2018**

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

   1. Examiner : ____________________ (Convener)

   2. Examiner : ____________________

3. Examiner : ____________________

4. Examiner : ____________________
(If any)

3. This Board of Examiners would be responsible for setting of question papers as per following details:

a) Name of Course : ________________________

b) Semester : ________________________

c) Name of the Paper: ________________________

d) Unique Paper Code: ________________________

e) Medium of setting the Question paper: English / English & Hindi Language

4. It would be the responsibility of the Convener to ensure that the paper is set as per the syllabus and the scheme of examination. The syllabus and the schemes of examination is available on the University of Delhi website and / or may be obtained from the Department concerned.

5. The three schemes of Undergraduate examination viz. ***three year semester mode, erstwhile FYUP Semester mode and examination for new UG admission having CBCS scheme are being held simultaneously,*** therefore the boards of examiners are required to be instructed to set question papers distinguishing clearly the mode for which paper setting is to be done as per Unique Paper Code alongwith relevant course content / syllabus, scheme of examinations, number of question papers required etc.

6. The board of examiners shall ensure the compliance of relevant guidelines for PWD candidates, wherever applicable. Para XV of the notification dated 28/01/2014 in this regard is reproduced below :-

"Alternative objective questions in lieu of descriptive questions should be provided for Hearing-Impaired persons, in additional to the existing policy of giving alternative questions in lieu of questions requiring visual inputs, for persons with Visual Impairment."

1. The Board of examiners shall be required to prepare the question papers in the following manner :-

- For **Three Years CBCS Examination;**

S. No.	Paper	No. of Sets Required
i.	All papers of Honours / Programme except Discipline Centered Course-I, II & Language Papers.	2 Sets
ii.	All discipline Centered Courses I & II Papers (Except discipline Centered Courses / Papers offered in B. Com (H) & B. Com (Prog.)	4 Sets
iii.	Language papers offered in B. A. (Prog.)	4 Sets

8. Each page of such set of question papers is required to be certified by the Board of Examiners at an appropriate place as mark of authenticity. **But the personal details such as Name of Deptt./ College of paper setter, telephone number, address etc. must not be mentioned on the question paper**.

9. **While undertaking this exercise, you are required to take into consideration the following instructions ;**

(i) When a teacher is acting a part of the Board of Examiners, it should be ensured that no near relations (wife, husband, son, daughter, brother, sister, nephew, niece, sister-in-law or daughter-in-law, brother-in-law etc.) of the teacher is a candidate for the examinations under reference. A certificate is required to be signed by all concerned for this purpose. A copy of the certificate to be filled in by the members of the Board is enclosed as Appendix-I to this letter.

(ii) These two sets of question papers should not have questions common in any of the papers. This means, there should not be any repetition of questions in the sets.

(iii) Utmost care and attention would be required while setting of question papers by the Board of Examiners with special reference to the course content/syllabus, scheme of examinations etc. The convener of the Board of Examiners should ensure such matters.

(iv) **The question papers set by a Board of Examiners must be moderated by the Moderation Committee at the department level.**

(v) Following technical specifications should be strictly adhere to while setting the question papers:

(a)	Font (in English)	-	Times New Roman
(b)	Font (in Hindi)	-	unicode / kruti dev
(c)	Font size	-	12
(d)	Space	-	Single Space
(e)	Paper size	-	Standard A4 size
(f)	Printing	-	On one side of the page
(g)	Certification/ Authentication	-	On the back of each page

(vi) A standard format for the first page of question paper is enclosed for ready reference as Appendix-II. However, instructions to the examinee relating to the structure of the question paper has to be specified at the time of setting of question papers by the Board of Examiners based on the syllabus and scheme of examination prescribed for the subject / paper like use of calculator, graph paper, log tables etc.

(vii) Utmost care should be given to ensure that name and identity of the Board of Examiners are not disclosed as it is strictly confidential to facilitate free & fair conduct of examination.

(viii) Translation is required to be carried out wherever needed. Each set of question paper, either in English or bilingual (English and Hindi) is to be packed in a separate sealed envelope alongwith a soft copy of the entire content of that corresponding set of Question Paper in Microsoft Word Format in the form of a CD. **Please note that hand written scanned copy of the question papers will not be accepted under any circumstances.**

(ix) There will be separate envelopes - for each set of question paper and it's CD. These envelopes should be signed and sealed separately and put inside a larger envelope and signed and sealed again by the Board of Examiners. The envelopes must be superscribed with the following details :

(a) Name of the Department

(b) Name of the Course

(c) Name of the Paper

(d) Semester

(e) Unique Paper Code

Such sealed packet should be handed over to the Head of the Department by the convener of the Board of Examiners immediately on completion of the exercise. The Board of Examiners would be entirely responsible for this exercise.

10. You would be required to submit the remuneration bill for the members of the Board of Examiners to the Head of Department. Necessary proforma for settlement of claim/settlement of advance alongwith guidelines of remuneration payable to the teachers in this regard is enclosed herewith for appropriate usage Appendix-III. However, conveyance charges for maximum 03 visits would be allowed to the Examiner / convener per paper.

11. Matters relating to South Delhi Campus should be taken up with the Deputy Registrar, Examinations (South Delhi Campus) as such matters are separately dealt by the Examination Office of the South Delhi Campus.

12. **The last date of submission of the question papers is October 15, 2018.** It should be ensured that the question paper reaches the Head of the Department by the stipulated date to ensure timely conduct of the examination under reference.

13. It will be highly appreciated if you kindly go through the entire contents of this letter and ensure that the procedure mentioned overleaf and above is scrupulously adhered to.

14. List of papers for which question papers have to be set, schedule of remuneration for such work alongwith various proforma / envelope etc. as mentioned in the body of the letter is enclosed for appropriate usage.

Yours faithfully,

(Head of the Department)

Encl.: As above

Appendix-II

Format of the First page of a Model Question Paper in A4 size page

Unique Paper Code	:	
Name of the Paper	:	
Name of the Course	:	
Semester	:	
Duration	:	_______ hours
Maximum Marks	:	_______ Marks

Instructions for Candidates

UNIVERSITY OF DELHI EXAMINATION – I / II CHECK-LIST FOR CONVENER

S. No.	Type of Item	Quantity	Remarks Yes / No
1.	Letter of Appointment of Convener from the HOD	01	
2.	Copy of Undertaking of the examiners / paper setters to be submitted to the Head of the Department (Appendix-I) .	04	Yes
3.	Format of First Page of Question Paper for essential details (Appendix-II).	03	Yes
4.	Remuneration claim form for examiners / paper setters (Appendix-III)	03	Yes
5.	Envelops along with proper superscription of details of Unique Paper Code etc. for each set of question paper to be set (a & b as the case may be) size of [10"x12"] .	02 / 04	Yes
6.	CD covers along with CD's for each paper. CD cover should mention Set-A & Set-B along with details of Unique Paper Code etc.	02 / 04	Yes
7.	Envelope along with proper superscription of details of Unique Paper Code etc. in which all the set of the question papers is to be put by the convener and sent to the Head of the Department confidentially. [12"x16"]	01	Yes
8.	Envelope for enclosing remuneration claim bills	02 / 04	Yes

Annexure-III

University of Delhi

(To be filled up by the Head of the Department
and returned to the Examination Office within 10 days of the receipt of the latter)

*I have not found any incompleteness (such as any missing papers etc.) or any inaccuracy in the details of papers to be set by the Department as provided by the Examination Office of the University in Annexure I.

OR

*I have found the following discrepancies in the details provided by the Examination Office of the University in Annexure - I. Kindly make the necessary corrections in the details of the papers to be set by the Department which is as follows. (Attach extra sheets, if necessary)

*Strike out whichever is not applicable

Head of the Department

Department of ________
____

OSD - Examinations

BY HAND

CONFIDENTIAL

No. ____________

Date: 01.10.18

To

Dr. Nimisha Sinha
The Convener/ Examiner,
S.V.C.
New Delhi

Subject: Request for setting of question papers by the Board of Examiners (paper setters) **for forthcoming Undergraduate Three Year CBCS Semester - I / III / V Examinations, Nov / Dec - 2018 for the Academic Year 2018-19- regarding**

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

"Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

1.	Examiner	:	Dr. Nimisha Sinha, SVC (Convener)
2.	Examiner	:	Dr. Meenakshi Vachher, IHE
3.	Examiner	:	Dr. Neeraj Dohare, DRC
4.	Examiner (If any)	:	____________

CONFIDENTIAL

BY HA[illegible]

No. ____________

Date: 13th March 2019

To

Dr. Nimisha Sinha
The Convener/ Examiner,
S.V. College
New Delhi

Subject: Request for setting of question papers by the Board of Examiners (paper setters) for the following forthcoming Undergraduate Examination to be held in May / June 2019 for the Academic Year 2018-19 :-

(i) Three year Semester Examination – II / IV / VI
(ii) Erstwhile FYUP Semester Examination – IV / VI / VIII

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. **The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.**

1.	Examiner	:	**Dr. Nimisha Sinha (SVC) (Convener)**
2.	Examiner	:	**Dr. Vanshika Lumb (DBC)**
3.	Examiner	:	**Dr. Leena Vig (DRC)**
4.	Examiner (If any)	:	____________

13. It will be highly appreciated if you kindly go through the entire contents of this letter and ensure that the procedure mentioned overleaf and above is scrupulously adhered to.

14. List of papers for which question papers have to be set, schedule of remuneration for such work alongwith various proforma / envelope etc. as mentioned in the body of the letter is enclosed for appropriate usage.

Yours faithfully,

(Head of the Department)

Department of Biochemistry
Delhi University South Campus
New Delhi-110021

Encl.: <u>As above</u>

Copy to:

1. **Dr. Vanshika Lumb (DBC), Examiner I**

2. **Dr. Leena Vig (DRC), Examiner II**

3. ______________________, Examiner *III (if any)*

LOCF:DU, Login Credentials for LOCF

1 message

LOCF:DU Team <ugcr2019@du.ac.in> Tue, Mar 19, 2019 at 2:56 PM
Reply-to: LOCF:DU Team <ugcr2019@du.ac.in>
To: Nimisha Sinha <nimisha10@gmail.com>

Dear Nimisha Sinha,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Molecules of Life Course Code BCH C-1 in Programme (CBCS) B.SC.(HONS.) BIOCHEMISTRY.

Login URL: ugcr2019.du.ac.in
Username: nimisha10@gmail.com
Password: 6521

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

LOCF:DU, Login Credentials for LOCF

1 message

LOCF:DU Team <ugcr2019@du.ac.in>
Reply-to: LOCF:DU Team <ugcr2019@du.ac.in>
To: Nimisha Sinha <nimisha10@gmail.com>

Tue, Apr 9, 2019 at 12:14 PM

Dear Nimisha Sinha,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Plant Biochemistry Course Code BCH DSE-5 in Programme (CBCS) B.SC.(HONS.) BIOCHEMISTRY.

Login credentials are same as sent you in past

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

Bhaskaracharya College of Applied Sciences
(University of Delhi)
Sector-2, Dwarka, New Delhi – 110 075.

Ref. No. BCAS/7(1)/College Exams/MJ19/749 Date: 18.04.2019
GE-E1

Dr. Nimisha Sinha
A-64, Abhiyan Apartments,
Plot No. 15, Sector-12,
Dwarka, New Delhi - 110075.
935074184
nimisha10@gmail.com

Dear Sir/Madam,

I am pleased to inform you that you have been appointed as an **External Examiner** for conducting practical examination, as per the following details:

Examiner Code	:	**BCAS/MJ19/9902**
Course	:	**GE Paper (Biochemistry) - II Semester**
Paper Code	:	**32495902**
Paper Title	:	**Proteins and Enzymes**
Date of Exam	:	**29-04-2019**
Time	:	**09:00 a.m. onwards**
Internal Examiner	:	**Dr. Anita Sondhi** **Associate Professor** **Department of Biochemistry** **BCAS**

You are requested to confirm the acceptance and also requested to reach the College on time to conduct the practical examination smoothly.

Thanking you,

Yours sincerely,

Manu Kalaria

(Coordinator)

LOCF:DU, Login Credentials for LOCF

1 message

LOCF:DU Team <ugcr2019@du.ac.in>
Reply-to: LOCF:DU Team <ugcr2019@du.ac.in>
To: Dr Nimisha Sinha <nimishasinha@svc.ac.in>

Mon, Apr 15, 2019 at 2:44 PM

Dear Dr Nimisha Sinha,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Biotechnology Course Code BS DSE-3 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

Login credentials are same as sent you in past

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

CONFIDENTIAL

BY HAND

No. ____________

Date: 27th February 2018

To
Dr. Nitika Kaushal
Convener
Sri Venkateswara College
New Delhi

Subject: **Request for setting of question papers by the Board of Examiners (paper setters) for the following forthcoming Undergraduate Examination to be held in May / June 2018 for the Academic Year 2017-2018 :-**

(i) Three year Semester Examination – II / IV / VI
(ii) Three year CBCS Semester Examination – II / IV / VI

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

   1. Examiner : **Dr. Nitika Kaushal, SVC** (Convener)
   2. Examiner : **Dr. Renu Baweja, SHC**
   3. Examiner : **Dr. Rashmi Dudeja, DBC**
   4. Examiner (If any) : ____________

3. This Board of Examiners would be responsible for setting of question papers as per following details:

   a) Name of Course : **B.Sc. (Hons) Biochemistry**
   b) Semester : **VI**
   c) Name of the Paper : **Basic Microbiology**
   d) Unique Paper Code : **32497908**
   e) Medium of setting the Question paper: **English**

4. **It would be the responsibility of the Convener to ensure that the paper is set as per the syllabus and the scheme of examination. The syllabus and the schemes of examination is available on the University of Delhi website and / or may be obtained from the Department concerned.**

BY HAND

CONFIDENTIAL

No. ________

Date: 01.10.18

To

Dr. Nitika Kaushal
The Convener/ Examiner,
SVC
New Delhi

Subject: Request for setting of question papers by the Board of Examiners (paper setters) **for forthcoming Undergraduate Three Year CBCS Semester - I / III / V Examinations, Nov / Dec - 2018 for the Academic Year 2018-19- regarding**

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

1.	Examiner	:	Dr. Nitika Kaushal, SVC (Convener)
2.	Examiner	:	Dr. Jayita Thakur, SHC
3.	Examiner	:	Dr. Anita Mangla, DRC
4.	Examiner (If any)	:	________

3. This Board of Examiners would be responsible for setting of question papers as per following details:

   a) Name of Course : B.Sc. (Hons) Biochemistry

   b) Semester : V

   c) Name of the Paper: Molecular Basis of infectious diseases

   d) Unique Paper Code: 32497904

   e) Medium of setting the Question paper: **English** / English & Hindi Language

4. **It would be the responsibility of the Convener to ensure that the paper is set as per the syllabus and the scheme of examination. The syllabus and the schemes of examination is available on the University of Delhi website and / or may be obtained from the Department concerned.**

5. The three schemes of Undergraduate examination viz. ***three year semester mode, erstwhile FYUP Semester mode and examination for new UG admission having CBCS scheme are being held simultaneously,*** therefore the boards of examiners are required to be instructed to set question papers distinguishing clearly the mode for which paper setting is to be done as per Unique Paper Code alongwith relevant course content / syllabus, scheme of examinations, number of question papers required etc.

6. **The board of examiners shall ensure the compliance of relevant guidelines for PWD candidates, wherever applicable. Para XV of the notification dated 28/01/2014 in this regard is reproduced below :-**

   "Alternative objective questions in lieu of descriptive questions should be provided for Hearing-Impaired persons, in additional to the existing policy of giving alternative questions in lieu of questions requiring visual inputs, for persons with Visual Impairment."

CONFIDENTIAL BY HAND

No. ____________
Date: 13th March 2019

To

Dr. Nitika Kaushal
The Convener/ Examiner,
S.V. College
New Delhi

Subject: Request for setting of question papers by the Board of Examiners (paper setters) for the following forthcoming Undergraduate Examination to be held in May / June 2019 for the Academic Year 2018-19 :-

(i) Three year CBCS Semester Examination – II / IV / VI

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

1.	Examiner	:	**Dr. Nitika Kaushal (SVC)** (Convener)
2.	Examiner	:	**Dr. Rashmi Dudeja (DBC)**
3.	Examiner	:	**Dr. Radhika Gupta (DRC)**
4.	Examiner (If any)	:	____________

3. This Board of Examiners would be responsible for setting of question papers as per following details:

   a) Name of Course : B.Sc. (Hons) Biochemistry

   b) Semester : VI

   c) Name of the Paper: Molecular Basis of Infectious Human Diseases (DSE)

   d) Unique Paper Code: 32497904

   e) Medium of setting the Question paper: **English** / English & Hindi Language

4. **It would be the responsibility of the Convener to ensure that the paper is set as per the syllabus and the scheme of examination. The syllabus and the schemes of examination is available on the University of Delhi website and / or may be obtained from the Department concerned.**

5. The three schemes of Undergraduate examination viz. ***three year semester mode, erstwhile FYUP Semester mode and examination for new UG admission having CBCS scheme are being held simultaneously,*** therefore the boards of examiners are required to be instructed to set question papers distinguishing clearly the mode for which paper setting is to be done as per Unique Paper Code alongwith relevant course content / syllabus, scheme of examinations, number of question papers required etc.

6. **The board of examiners shall ensure the compliance of relevant guidelines for PWD candidates, wherever applicable. Para XV of the notification dated 28/01/2014 in this regard is reproduced below :-**

   "Alternative objective questions in lieu of descriptive questions should be provided for Hearing-Impaired persons, in additional to the existing policy of giving alternative questions in lieu of questions requiring visual inputs, for persons with Visual Impairment."

LOCF:DU, Login Credentials for LOCF

Inbox ×

LOCF:DU Team <ugcr2019@du.ac.in> Fri, 15 Mar 2019, 17:46
to me

Dear Nitika Kaushal,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Molecules of Life Course Code BCH C-1 in Programme (CBCS) B.SC.(HONS.) BIOCHEMISTRY.

LOCF:DU, Login Credentials for LOCF

Inbox ×

LOCF:DU Team <ugcr2019@du.ac.in> Tue, 9 Apr 2019, 12:03
to me

Dear Nitika Kaushal,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Advanced Cell Biology Course Code BCH DSE-2 in Programme (CBCS) B.SC.(HONS.) BIOCHEMISTRY.

Login credentials are same as sent you in past

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

LOCF:DU Team <ugcr2019@du.ac.in> Tue, 9 Apr 2019, 12:10
to me

Dear Nitika Kaushal,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Molecular Basis of Infectious Disease Course Code BCH DSE-4 in Programme (CBCS) B.SC.(HONS.) BIOCHEMISTRY.

...

Reply Forward

Inbox - nitikakaushalsvc@gmail.c × | LOCF:DU, Login Credentials for L ×

mail.google.com/mail/u/1/#search/locf/FMfcgxwBWSvRhDSMksVTFsFbvBVBRcJH

Gmail

locf

Compose

Inbox 115
Starred
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Important
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Drafts 2
Categories
Social 644
Updates 2,236
Forums

Meet
New meeting
Join a meeting

Hangouts
Nitika

No recent chats
Start a new one

31 of 34

LOCF:DU, Login Credentials for LOCF

Inbox ×

LOCF:DU Team <ugcr2019@du.ac.in> Wed, 27 Mar 2019, 13:53

to me

Dear Dr Nitika Kaushal,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Concepts in Cell Biology Course Code BS C6 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

Login credentials are same as sent you in past

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

LOCF:DU Team <ugcr2019@du.ac.in> Wed, 27 Mar 2019, 14:15

to me

Dear Dr Nitika Kaushal,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Metabolism and Integration Course Code BS C10 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

...

LOCF:DU Team <ugcr2019@du.ac.in> Wed, 27 Mar 2019, 14:34

to me

Dear Dr. Nitika Kaushal,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Defense Mechanisms Course Code BS C13 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

...

Vander's human p....pdf

Show all

Type here to search

ENG 12:59 08-04-2021

Inbox - nitikakaushalsvc@gmail.c × LOCF:DU, Login Credentials for L ×

mail.google.com/mail/u/1/#search/locf/FMfcgxwCgCTpbhDlhQGlpqTBqphLMWQh

Gmail

locf

Compose

Inbox 115
Starred
Snoozed
Important
Sent
Drafts 2
Categories
Social 644
Updates 2,236
Forums

Meet
New meeting
Join a meeting

Hangouts
Nitika

No recent chats
Start a new one

23 of 34

LOCF:DU, Login Credentials for LOCF Inbox ×

LOCF:DU Team <ugcr2019@du.ac.in> Mon, 15 Apr 2019, 14:44
to me

Dear Dr Nitika Kaushal,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Biotechnology Course Code BS DSE-3 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

Login credentials are same as sent you in past

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

LOCF:DU Team <ugcr2019@du.ac.in> Mon, 15 Apr 2019, 18:09
to me

Dear Dr Nitika Kaushal,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Microbiology Course Code BS DSE-8 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

...

Reply Forward

Vander's human p....pdf Show all

Type here to search 13:00 08-04-2021 ENG

2019-20 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

CONFIDENTIAL

BY HAND

To

No. ________
Date: 01. 10. 18

Dr. Nandita Narayansamy
The Convener/ Examiner,
SVC
New Delhi

Subject: Request for setting of question papers by the Board of Examiners (paper setters) **for forthcoming Undergraduate Three Year CBCS Semester - I / III / V Examinations, Nov / Dec - 2018 for the Academic Year 2018-19- regarding**

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

1.	Examiner	:	Dr. Nandita Narayansamy, SVC (Convener)
2.	Examiner	:	Dr. Taruna Arora, IHE
3.	Examiner	:	Dr. Radhika Gupta, DRC
4.	Examiner (If any)	:	________________

2019-20 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

SRI VENKATESWARA COLLEGE
DHAULA KUAN, NEW DELHI-110021

Dated: - 26.11.2018

OFFICE ORDER

The following teachers are appointed as Deputy Coordinators for Central Evaluation Centre for the Semester Examinations to be held in month of November/December 2018.

1. Dr. R.P.Singh
   Associate Professor
   Department of Chemistry

2. Dr. Nandita Narayanasamy
   Associate Professor
   Department of Biochemistry

3. Dr. Namita Pandey
   Associate Professor
   Department of Political Science

PRINCIPAL
Coordinator, CEC/SVC

Bot./19/30
25.03.2019

To

Dr. Kuldeep Kumar Koul
The Convener
Hindu College
North Campus
University of Delhi
Delhi - 110007

Subject: Request for setting of question papers by the Board of Examiners (paper setters) for the following forthcoming Undergraduate Examination to be held in May / June 2019 for the Academic Year 2018-19 :-

(i) Three year Semester Examination – II / IV / VI
(ii) Erstwhile FYUP Semester Examination – IV / VI / VIII

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

   1. Examiner : Dr. Kuldeep Kumar Koul, Hindu (9718383989) (Convener)

   2. Examiner : Dr. Romila Rawat Bisht, HRC (9999994835)

   3. Examiner : Dr. Sunita Yadav, SVC (9899749008)

   4. Examiner (If any) : ____________________

Bot./19/19
19.03.2019

To

Dr. Kalyani Krishna
The Convener
Sri Venkateswara College
Dhaula Kuan, New Delhi - 110021

Subject: Request for setting of question papers by the Board of Examiners (paper setters) for the following forthcoming Undergraduate Examination to be held in May / June 2019 for the Academic Year 2018-19 :-

(i) Three year CBCS Semester Examination – II / IV / VI

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

   1. Examiner : Dr. Kalyani Krishna, SVC (9810637363) (Convener)
   2. Examiner : Dr. Rajesh Kumar, Hindu (9810344831)
   3. Examiner : Dr. Sunita Yadav, SVC (9899749008)
   4. Examiner (If any) : ____________________

दयाल सिंह कॉलेज
(दिल्ली विश्वविद्यालय)
लोधी रोड, नई दिल्ली – 110003
दूरभाष / फैक्स : 24367819, 24365948 / 24365606
ईमेल : principal@dsc.du.ac.in
वेबसाइट : www.dsc.du.ac.in

NAAC Accredited 'A' Grade
NIRF - 2017 All India 8th Rank

DYAL SINGH COLLEGE
(University of Delhi)
Lodhi Road, New Delhi – 110003
Telephone/ Fax : 24367819,24365948/ 24365606
Email : principal@dsc.du.ac.in
Website : www.dsc.du.ac.in

DEPTT OF BOTANY

Date:

Dr Sunita Yadav
Sri Venkateshwar College
University of Delhi.

Dear ~~sir~~/Madam,

In accordance with the University Notification and your appointment as external Examiner in respect of GE (Hons.) Course Sem..III...Plant Physiology.................................... Practical Examination. You are requested to conduct the Examination as per details given below.

Examination/Lab.	Date	Time (Morn/Eve)
G.E. III Sem (Hons.)/ Lab P	17.11.18	9.30 a.m – 12.30 p.m.

SUPERINTENDENT
PRACTICAL EXAMINATIONS
DEPT. OF BOTANY.

31-Oct-18 1:09 PM

हिंदी-विभाग
दिल्ली विश्वविद्यालय
दिल्ली-110007

दिनांक : 29.3.2019

प्रमाणित किया जाता है कि बी.ए. स्नातक स्तर के परीक्षा-कार्य हेतु विभिन्न महाविद्यालयों के प्रभारी, हिंदी विभाग/प्रतिनिधि की अध्यक्ष, हिंदी विभाग द्वारा बुलाई गई एक आवश्यक बैठक दिनांक 29.3.2019 को पूर्वाह्न/अपराह्न 2:30 P.M. बजे हुई। जिसमें डॉ. राम किशोर यादव ...... कॉलेज ने भाग लिया।

29/3/19

प्रो० मोहन / Prof. MOHAN
(प्रो. मोहन) Head
हिंदी विभाग / Department of hindi
अध्यक्ष, हिन्दी-विभाग
दिल्ली विश्वविद्यालय दिल्ली-110007
University of Delhi, Delhi-110007

LOCF
AdminPanel (http://ugcr2019.du.ac.in/index.php/index)

Department of Hindi

DR. RAM KISHOR YADAV
Working Group Member

Guidelines for Course Coordinator and Working group members

ord)

Welcome to the revision of Under Graduate Curriculum, under UGC-LOCF, 2019!

The task involves:

1. Revising the existing Under Graduate programmes of Delhi University in the light of UGC's Learning Outcome-based Curriculum Framework (UGC-LOCF). Please go through the guidelines of UGC-LOCF (https://www.ugc.ac.in/pdfnews/4598476_LOCF-UG.pdf)

2. Learning outcomes specify what graduates completing a particular programme of study are expected to know, understand and be able to do at the end of their programme of study. The expected learning outcomes are used as reference points that would help formulate graduate attributes, qualification descriptors, programme learning outcomes and course learning outcomes which in turn will help in curriculum planning and development, and in the design, delivery and review of academic programmes.

3. Aspects that need attention:

a. Defining and listing Learning Outcomes for Under Graduate Education: Fulfilment of NAAC/UGC requirements

b. Revision of Courses and Filling the gaps in the Programme/Course

c. Bridging of UG Curriculum with Sr. Sec. School curriculum and PG courses (Refer NCERT books to know the entry level)

d. Providing more options for Generic Elective Papers

e. Further Strengthening

i. Inclusion of Research

ii. Widening the pool of Skill Enhancement Courses for better integration of Life Skills

f. Updating Reading List

i. Identifying Readings in other languages

ii. Providing Compulsory and Additional Reading Lists of each course keeping in mind the level of students and availability of time

iii. Identifying Classic Readings for each Course

4 All members have been provided access to participate in the revision process. There will be 1 Course Coordinator and 3 Working Group members for each course. A provision of adding 2 students has also been provided. The students must be involved in the revision process.

LOCF (http://ugcr2019.du.ac.in/index.php/index)

DR. RAM KISHOR YADAV
Working Group Member

Department of Hindi

5. The Course Coordinator will be responsible for the overall working of the group. S(he) will ensure the coordination between the Working Group members to meet the expected outcomes within the scheduled time frame.

6. Each Working Group member can add, delete, modify, edit their own text. S(he) can [illegible] other members, but cannot edit other member's work.

7. The Course Coordinator can view, modify, and edit the work of every member.

8. The overall responsibility of the compiling and preparing the final draft of the Course will be with the Course Coordinator. The draft submitted by the Course Coordinator will be considered as FINAL.

ord)

9. **The exiting curriculum has to be considered for the revision purpose.**

10. **Please Note: The revision process involves revision of content in the light of UGC-LOCF, and updating the reading lists. No structural changes on the set template can be done.**

11. **The last date for the FIRST DRAFT of the Course is March 29, 2019.** The Course Coordinators must submit the courses before this date.

For any clarification, you may email on ugcr2019@du.ac.in. Alternatively, call Dr. Pankaj Arora (Convener, UGCRC-2019) at 9818787576 or Dr. Haneet Gandhi (Co-Converner, UGCRC-2019) at 9910688111.

Our best wishes to the entire team!

I undertake that I have read the Guidelines I Agree

Gmail

Ram Kishore Yadav <macramkishore.yadav@gmail.com>

LOCF:DU, Login Credentials for LOCF

LOCF:DU Team <ugcr2019@du.ac.in> Mon, Apr 29, 2019 at 12:08 PM
Reply-To: "LOCF:DU Team" <ugcr2019@du.ac.in>
To: "DR. RAM KISHORE YADAV" <macramkishore.yadav@gmail.com>

Dear DR. RAM KISHORE YADAV,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled à¤à¤¾à¤·à¤¾ à¤"à¤° à¤¸à¤®à¤¾à¤œ Course Code BAHHSEC07 in Programme (CBCS) B.A.(HONS.) HINDI.

Login credentials are same as sent you in past

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

BPGP1004Question Paper for the End Term Examination- May 2019,

Prof. H. C. Rai <coe_qp@galgotiasuniversity.edu.in>

Mon 4/29/2019 3:36 PM

To: santoshjnu@hotmail.com <santoshjnu@hotmail.com>

2 attachments (28 KB)

Mandate_ETE Format (1).docx; BPGP1004 - Shreesh Kumar Pathak.docx;

Dear Dr. Santosh Kumar Singh,

Greetings from Galgotias University!

It is my pleasure to inform you that you have been nominated to set the question paper for the End Term Examination, May 2019 for the following course(s):

School Name	**:**	**SLA**
Course Code	**:**	**BPGP1004**
Course Title	**:**	**INDIAN GOVERNMENT AND POLITICS**
Max. Marks	**:**	**100**
Duration of Exam	**:**	**3 Hrs.**
No. of sets	**:**	**TWO**

You are requested to Upload Question Paper and the marking scheme along with the solutions to numerical problems (if any). Kindly ensure that the question paper is evenly spread over the entire syllabus and is set as per the attached template. The syllabus, Undertaking form and the guidelines for question paper setting are attached.

You will be paid remuneration of Rs. 2000 for two question papers. However, if you are in a position to supply only one set of question paper then the remuneration will be Rs 1500/-. Kindly Upload the Question Paper along with the marking scheme in given link preferably in a week's time (Not later than 06/05/2019).

Undertaking Format:

https://drive.google.com/file/d/1BVYOffpR2KkAmvRic4BfehaGsgRZJS-B/view?usp=sharing

Guideline for Question Paper Setting:

https://drive.google.com/file/d/1jmui1SRFWqV5CohzRKyRl4RCj31OoAfT/view?usp=sharing

Question Paper: UPLOAD LINK

Thanks and Regards

Prof. H. C. Rai
Pro-VC, Galgotias University Uttar Pradesh
Greater Noida (U. P.)Plot No:1,
Sector-17/A,Yamuna Expressway,
Greater Noida, GB Nagar,UP-India.

LOCF:DU Team 18/04/2019

to me

From	LOCF:DU Team • ugcr2019@du.ac.in
Reply to	LOCF:DU Team • ugcr2019@du.ac.in
To	Dr Tabassum Afshan • tabassum .afshan88@gmail.com
Date	18 Apr 2019, 18:55
	Standard encryption (TLS). See security details

Dear Dr Tabassum Afshan,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Medicinal Botany Course Code BS SEC-1 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

Login URL: ugcr2019.du.ac.in
Username: tabassum.afshan88@gmail.com
Password: 9408

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

Reply | Reply all | Forward

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

No. 42173923/32173902/32173923
Date: 5/4/19

To

Dr. Sarath Babu
The Convener/ ~~Examiner~~,
Gargi College
University of Delhi

Subject: Request for setting of question papers by the Board of Examiners (paper setters) for the following forthcoming Undergraduate Examination to be held in May / June 2019 for the Academic Year 2018-19 :-

(i) **Three year CBCS Semester Examination – II / IV / VI**

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

   1. Examiner : Dr. Sarath Babu, (Convener) Gargi college
   2. Examiner : Dr. Sangita Aggarwal, ARSD College
   3. Examiner : Dr. Devendra kumar, SV College
   4. Examiner (If any) : ________________

No. ______________ 34(i)
Date: ______________

//

To

Dr. Vartika Mathur
The Convener/~~Examiner~~,
SVC
____

Subject: Request for setting of question papers by the Board of Examiners (paper setters) for forthcoming Undergraduate Three Year CBCS Semester - ~~I / III /~~ V Examinations, Nov / Dec - 2018 for the Academic Year 2018-19- regarding

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

1.	Examiner	:	Dr. Vartika Mathur (Convener) SVC
2.	Examiner	:	Dr. K. Dabas (Sri Aurobindo) 9654269354
3.	Examiner	:	Dr. Ojit M (Ramjas) 9971328910
4.	Examiner (If any)	:	______________

34(ii)

3. This Board of Examiners would be responsible for setting of question papers as per following details:

   a) Name of Course : B.Sc (Life Science) Exam. 2018

   b) Semester : V . DSE

   c) Name of the Paper: DSE: Applied Zoology

   d) Unique Paper Code: 42237905

   e) Medium of setting the Question paper: English / English & Hindi Language

4. **It would be the responsibility of the Convener to ensure that the paper is set as per the syllabus and the scheme of examination. The syllabus and the schemes of examination is available on the University of Delhi website and / or may be obtained from the Department concerned.**

5. The three schemes of Undergraduate examination viz. *three year semester mode, erstwhile FYUP Semester mode and examination for new UG admission having CBCS scheme are being held simultaneously,* therefore the boards of examiners are required to be instructed to set question papers distinguishing clearly the mode for which paper setting is to be done as per Unique Paper Code alongwith relevant course content / syllabus, scheme of examinations, number of question papers required etc.

6. **The board of examiners shall ensure the compliance of relevant guidelines for PWD candidates, wherever applicable. Para XV of the notification dated 28/01/2014 in this regard is reproduced below :-**

   "Alternative objective questions in lieu of descriptive questions should be provided for Hearing-Impaired persons, in additional to the existing policy of giving alternative questions in lieu of questions requiring visual inputs, for persons with Visual Impairment."

(33)

Confidential

DAULAT RAM COLLEGE
(UNIVERSITY OF DELHI)
4, Patel Marg, Maurice Nagar, Delhi-110007

Ex. code - 2001 | SVC | 06

DRC/11-Practical Exams/2018/Sem. – I, ~~III, V~~ Date:- 2-11-18

Dr. Vartika Mathur

Dept. of zoology

Sri Venkateswara College

D.U.

Dear ~~Sir~~/ Madam,

This is to inform you that University of Delhi has appointed you as an External/ ~~Internal~~ Examiner for the practical examination of B.Sc. Hons. / ~~Life Science~~ 1st year Paper Principles of Ecology of Semester I, ~~III, V~~. The practical examination is scheduled on 16-11-18 & 17-11-18 at 9.30 am in the Department of Zoology. Please report at the Centre at least half an hour before the start of the Examination.

Kindly acknowledge and confirm.

Thanking You,

Yours truly,

Gautam

Dr.NidhiGautam
Superintendent
Practical Examination Nov.2018
Daulat Ram College
Mobile No. -9868535813

S. Roy

Dr. Savita Roy
Principal

A. 37

P.G DEPARTMENT OF ENVIRONMENTAL SCIENCES

UNIVERSITY OF JAMMU

Baba Saheb Ambedkar Road, Jammu-180 006

No. JU/Env.Sc./18/ 314
Dt. 02-08-18

Dr. Vartika Mathur
Sri Venkateswara College
South Campus, University of Delhi
Benito Juarez Marg, Dhaula Kuan,
New Delhi – 110021, India
Tel: +91 9810386575; e-mail: vmathur@svc.ac.in

Sub.: Appointment as External Examiners

Dear Dr Mathur

It gives me pleasure to inform you that Hon'ble Vice Chancellor has appointed you as External Examiners for evaluating M.Sc Dissertation, Course No. PSESDC-401, Environmental Sciences which has been fixed on 08-08-2018 at 10 am. You are requested to convey your acceptance along with your travel itinerary so that necessary arrangement for your stay can be made.

With regards

Rampal 2.8.XVIII

(Prof. R. K. Rampal)
Head
Deptt. of Environmental Sciences
University of Jammu
JAMMU.

मिरांडा हाउस
MIRANDA HOUSE

मिरांडा हाउस
दिल्ली विश्वविद्यालय, दिल्ली-110007
MIRANDA HOUSE
University of Delhi 110007
Phone: 91-11-27666983, 91-11-27667367
E-mail: office@mirandahouse.ac.in
website: www.mirandahouse.ac.in

INTIMATION TO EXTERNAL EXAMINER FOR EVEN SEMESTER PRACTICAL EXAMINATION ACADEMIC YEAR 2018-19

Name: Dr. Vartika Mathur
Designation: Assistant Professor
Department: Zoology
College: Sri Venkateswara College

Greetings from Miranda House! As per the list of Examiners sent to Miranda House by Examination Branch, University of Delhi, you have been appointed External Examiner for the following University of Delhi CBCS Practical for the even semester, Academic year 2018-19. Details are given below:

Paper Name: Wildlife Conservation and Management
Course Name: B.Sc(H) Zoology, Sem-VI
Date (s):29-04-19(Batch-I) &29-04-19 (Batch-II)
Time: 9:30 AM (Batch-I), 12:30 PM(Batch-II)
Venue: Room No 247(Batch-I),
247(Batch II)Miranda House
Name of Internal Examiner: Dr.Jyoti Arora

Kindly acknowledge receipt and send your consent by return email.

With regards

Monika

Dr. Monika Sharma
Teacher-in-Charge
Department of Zoology

मिरांडा हाउस
MIRANDA HOUSE

मिरांडा हाउस
दिल्ली विश्वविद्यालय, दिल्ली-110007
MIRANDA HOUSE
University of Delhi 110007
Phone: 91-11-27666983, 91-11-27667367
E-mail: office@mirandahouse.ac.in
website: www.mirandahouse.ac.in

INTIMATION TO EXTERNAL EXAMINER FOR EVEN SEMESTER PRACTICAL EXAMINATION ACADEMIC YEAR 2018-19

Name: Dr.Mansi Verma
Designation: Assistant Professor
Department: Zoology
College: Sri VenkateswaraCollege

Greetings from Miranda House! As per the list of Examiners sent to Miranda House by Examination Branch, University of Delhi, you have been appointed External Examiner for the following University of Delhi CBCS Practical for the even semester, Academic year 2018-19. Details are given below:

Paper Name:Evolutionary Biology
Course Name: B.Sc(H) Zoology, Sem- VI
Date (s):23-04-19(Batch-I) &23-04-19 (Batch-II)
Time:09:00 AM (Batch-I), 12:00 PM(Batch-II)
Venue: Room No 239(Batch-I),
239(Batch II)Miranda House
Name of Internal Examiner: Dr. Simran Jit

Kindly acknowledge receipt and send your consent by return email.

With regards

Monika

Dr. Monika Sharma
Teacher-in-Charge
Department of Zoology

to me

Dear Dr Mansi Verma,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Concepts in Cell Biology Course Code BS C6 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

Login URL: ugcr2019.du.ac.in
Username: mansiverma20@gmail.com
Password: 4682

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

LOCF:DU, Login Credentials for LOCF Inbox x

LOCF:DU Team <ugcr2019@du.ac.in>

to me

Mon, Apr 15, 2019, 3:20 PM

Dear Dr Mansi Verma,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Bioinformatics Course Code BS SEC-3 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

Login credentials are same as sent you in past

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

LOCF:DU Team <ugcr2019@du.ac.in>

to me

Wed, Mar 27, 2019, 2:08 PM

Dear Dr Mansi Verma,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Concepts of Molecular Biology Course Code BS C9 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

Login credentials are same as sent you in past

No.Maths/2018/PS/26
Date: 04.10.2018

Sir/Madam,

1. You are appointed as a Convener/Examiner for setting of question papers as per following details:-

Convener	Examiner	Examiner
Vanita Jain **Maharaja Agrasen College** **9868725181**	**Richa Krishna** **JMC** **9810354271**	**Deepti Jain** **Sri Venketswara College** **9871413161**

2. The Board of Examiners will set question paper for the **CBCS (Other than B.Sc. (H) Mathematics** for the subject with the following details:

B.A. (PROG.) **SEMESTER V**

Unique Paper Code	Paper Name
62357502	**DSE- Differential Equations**

- Examinations to be held in the month of : November /December 2018
- Medium of setting the Question paper : English
- Submit Question paper in the department by **October 15, 2018**

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

   1. Examiner : ____________________ (Convener)

   2. Examiner : ____________________

3. Examiner : ____________________

4. Examiner : ____________________
(If any)

3. This Board of Examiners would be responsible for setting of question papers as per following details:

a) Name of Course : ________________________

b) Semester : ________________________

c) Name of the Paper: ________________________

d) Unique Paper Code: ________________________

e) Medium of setting the Question paper: English / English & Hindi Language

4. It would be the responsibility of the Convener to ensure that the paper is set as per the syllabus and the scheme of examination. The syllabus and the schemes of examination is available on the University of Delhi website and / or may be obtained from the Department concerned.

5. The three schemes of Undergraduate examination viz. ***three year semester mode, erstwhile FYUP Semester mode and examination for new UG admission having CBCS scheme are being held simultaneously,*** therefore the boards of examiners are required to be instructed to set question papers distinguishing clearly the mode for which paper setting is to be done as per Unique Paper Code alongwith relevant course content / syllabus, scheme of examinations, number of question papers required etc.

6. The board of examiners shall ensure the compliance of relevant guidelines for PWD candidates, wherever applicable. Para XV of the notification dated 28/01/2014 in this regard is reproduced below :-

"Alternative objective questions in lieu of descriptive questions should be provided for Hearing-Impaired persons, in additional to the existing policy of giving alternative questions in lieu of questions requiring visual inputs, for persons with Visual Impairment."

1. The Board of examiners shall be required to prepare the question papers in the following manner :-

- For **Three Years CBCS Examination;**

S. No.	Paper	No. of Sets Required
i.	All papers of Honours / Programme except Discipline Centered Course-I, II & Language Papers.	2 Sets
ii.	All discipline Centered Courses I & II Papers (Except discipline Centered Courses / Papers offered in B. Com (H) & B. Com (Prog.)	4 Sets
iii.	Language papers offered in B. A. (Prog.)	4 Sets

8. Each page of such set of question papers is required to be certified by the Board of Examiners at an appropriate place as mark of authenticity. **But the personal details such as Name of Deptt./ College of paper setter, telephone number, address etc. must not be mentioned on the question paper**.

9. **While undertaking this exercise, you are required to take into consideration the following instructions ;**

(i) When a teacher is acting a part of the Board of Examiners, it should be ensured that no near relations (wife, husband, son, daughter, brother, sister, nephew, niece, sister-in-law or daughter-in-law, brother-in-law etc.) of the teacher is a candidate for the examinations under reference. A certificate is required to be signed by all concerned for this purpose. A copy of the certificate to be filled in by the members of the Board is enclosed as Appendix-I to this letter.

(ii) These two sets of question papers should not have questions common in any of the papers. This means, there should not be any repetition of questions in the sets.

(iii) Utmost care and attention would be required while setting of question papers by the Board of Examiners with special reference to the course content/syllabus, scheme of examinations etc. The convener of the Board of Examiners should ensure such matters.

(iv) **The question papers set by a Board of Examiners must be moderated by the Moderation Committee at the department level.**

(v) Following technical specifications should be strictly adhere to while setting the question papers:

(a)	Font (in English)	-	Times New Roman
(b)	Font (in Hindi)	-	unicode / kruti dev
(c)	Font size	-	12
(d)	Space	-	Single Space
(e)	Paper size	-	Standard A4 size
(f)	Printing	-	On one side of the page
(g)	Certification/ Authentication	-	On the back of each page

(vi) A standard format for the first page of question paper is enclosed for ready reference as Appendix-II. However, instructions to the examinee relating to the structure of the question paper has to be specified at the time of setting of question papers by the Board of Examiners based on the syllabus and scheme of examination prescribed for the subject / paper like use of calculator, graph paper, log tables etc.

(vii) Utmost care should be given to ensure that name and identity of the Board of Examiners are not disclosed as it is strictly confidential to facilitate free & fair conduct of examination.

(viii) Translation is required to be carried out wherever needed. Each set of question paper, either in English or bilingual (English and Hindi) is to be packed in a separate sealed envelope alongwith a soft copy of the entire content of that corresponding set of Question Paper in Microsoft Word Format in the form of a CD. **Please note that hand written scanned copy of the question papers will not be accepted under any circumstances.**

(ix) There will be separate envelopes - for each set of question paper and it's CD. These envelopes should be signed and sealed separately and put inside a larger envelope and signed and sealed again by the Board of Examiners. The envelopes must be superscribed with the following details :

(a) Name of the Department

(b) Name of the Course

(c) Name of the Paper

(d) Semester

(e) Unique Paper Code

Such sealed packet should be handed over to the Head of the Department by the convener of the Board of Examiners immediately on completion of the exercise. The Board of Examiners would be entirely responsible for this exercise.

10. You would be required to submit the remuneration bill for the members of the Board of Examiners to the Head of Department. Necessary proforma for settlement of claim/settlement of advance alongwith guidelines of remuneration payable to the teachers in this regard is enclosed herewith for appropriate usage Appendix-III. However, conveyance charges for maximum 03 visits would be allowed to the Examiner / convener per paper.

11. Matters relating to South Delhi Campus should be taken up with the Deputy Registrar, Examinations (South Delhi Campus) as such matters are separately dealt by the Examination Office of the South Delhi Campus.

12. **The last date of submission of the question papers is October 15, 2018.** It should be ensured that the question paper reaches the Head of the Department by the stipulated date to ensure timely conduct of the examination under reference.

13. It will be highly appreciated if you kindly go through the entire contents of this letter and ensure that the procedure mentioned overleaf and above is scrupulously adhered to.

14. List of papers for which question papers have to be set, schedule of remuneration for such work alongwith various proforma / envelope etc. as mentioned in the body of the letter is enclosed for appropriate usage.

Yours faithfully,

(Head of the Department)

Encl.: As above

Appendix-II

Format of the First page of a Model Question Paper in A4 size page

Unique Paper Code	:	
Name of the Paper	:	
Name of the Course	:	
Semester	:	
Duration	:	________ hours
Maximum Marks	:	________ Marks

Instructions for Candidates

UNIVERSITY OF DELHI EXAMINATION – I / II CHECK-LIST FOR CONVENER

S. No.	Type of Item	Quantity	Remarks Yes / No
1.	Letter of Appointment of Convener from the HOD	01	
2.	Copy of Undertaking of the examiners / paper setters to be submitted to the Head of the Department (Appendix-I) .	04	Yes
3.	Format of First Page of Question Paper for essential details (Appendix-II).	03	Yes
4.	Remuneration claim form for examiners / paper setters (Appendix-III)	03	Yes
5.	Envelops along with proper superscription of details of Unique Paper Code etc. for each set of question paper to be set (a & b as the case may be) size of [10"x12"] .	02 / 04	Yes
6.	CD covers along with CD's for each paper. CD cover should mention Set-A & Set-B along with details of Unique Paper Code etc.	02 / 04	Yes
7.	Envelope along with proper superscription of details of Unique Paper Code etc. in which all the set of the question papers is to be put by the convener and sent to the Head of the Department confidentially. [12"x16"]	01	Yes
8.	Envelope for enclosing remuneration claim bills	02 / 04	Yes

Annexure-III

University of Delhi

(To be filled up by the Head of the Department
and returned to the Examination Office within 10 days of the receipt of the latter)

*I have not found any incompleteness (such as any missing papers etc.) or any inaccuracy in the details of papers to be set by the Department as provided by the Examination Office of the University in Annexure I.

OR

*I have found the following discrepancies in the details provided by the Examination Office of the University in Annexure - I. Kindly make the necessary corrections in the details of the papers to be set by the Department which is as follows. (Attach extra sheets, if necessary)

*Strike out whichever is not applicable

Head of the Department

Department of ________
____

OSD - Examinations

No.Maths/2019/CBCS/01
Date: 12.03.2019

Sir/Madam,

1. You are appointed as a Convener/Examiner for setting of question papers as per following details:-

Convener	Examiner	Examiner
Manjari Srivastava MH 9899228986	Deepti Jain Sri Venkateshwar College 9871413161	Bharti Talwar Gargi College 9811095485

2. The Board of Examiners will set question paper for the **CBCS (B.Sc. (H) Mathematics** for the subject with the following details:

CBCS B.Sc. (Hons.) Mathematics **SEMESTER II**

Unique Paper Code	Paper Name
32351201	C3- Real Analysis

- Examinations to be held in the month of : May / June 2019
- Medium of setting the Question paper : English
- Submit Question paper in the department by March 19, 2019

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

   1. Examiner : ____________________ (Convener)

2. Examiner : ___________________

3. Examiner : ___________________

4. Examiner : ___________________
(If any)

3. This Board of Examiners would be responsible for setting of question papers as per following details:

a) Name of Course : _______________________

b) Semester : _______________________

c) Name of the Paper: _______________________

d) Unique Paper Code: _______________________

e) Medium of setting the Question paper: English / English & Hindi Language

4. It would be the responsibility of the Convener to ensure that the paper is set as per the syllabus and the scheme of examination. The syllabus and the schemes of examination is available on the University of Delhi website and / or may be obtained from the Department concerned.

5. The three schemes of Undergraduate examination viz. ***three year semester mode, erstwhile FYUP Semester modeand examination for new UG admission having CBCS scheme are being held simultaneously,*** therefore the boards of examiners are required to be instructed to set question papers distinguishing clearly the mode for which paper setting is to be done as per Unique Paper Code alongwith relevant course content / syllabus, scheme of examinations, number of question papers required etc.

6. The board of examiners shall ensure the compliance of relevant guidelines for PWD candidates, wherever applicable. Para XV of the notification dated 28/01/2014 in this regard is reproduced below :-

"Alternative objective questions in lieu of descriptive questions should be provided for Hearing-Impaired persons, in additional to the existing policy

of giving alternative questions in lieu of questions requiring visual inputs, for persons with Visual Impairment."

7. The Board of examiners shall be required to prepare the question papers in the following manner :-

(i) For **Three Years Semester Examination ;**

Two sets of question papers for Hons. / **Four sets** for B. A. (Prog.)Courses. There should not be any preference of any particular set. The sets should be numbered as A& B (as the case may be) for Hons. Courses and A, B, C & D for Programme Courses.

(ii) For **Three Years CBCS Examination;**

S. No.	Paper	No. of Sets Required
i.	All papers of Honours / Programme except Discipline Centered Course-I, II & Language Papers.	2 Sets
ii.	All discipline Centered Courses I & II Papers (Except discipline Centered Courses / Papers offered in B. Com (H) & B. Com (Prog.)	4 Sets
iii.	Language papers offered in B. A. (Prog.)	4 Sets

8. Each page of such set of question papers is required to be certified by the Board of Examiners at an appropriate place as mark of authenticity. **But the personal details such as Name of Deptt./ College of paper setter, telephone number, address etc. must not be mentioned on the question paper**.

9. **While undertaking this exercise, you are required to take into consideration the following instructions;**

(i) When a teacher is acting a part of the Board of Examiners, it should be ensured that no near relations (wife, husband, son, daughter, brother, sister, nephew, niece, sister-in-law or daughter-in-law, brother-in-law etc.) of the teacher is a candidate for the examinations under reference. A certificate is required to be signed by all concerned for this purpose. A copy of the certificate to be filled in by the members of the Board is enclosed as Appendix-I to this letter.

(ii) These two sets of question papers should not have questions common in any of the papers. This means, there should not be any repetition of questions in the sets.

(iii) Utmost care and attention would be required while setting of question papers by the Board of Examiners with special reference to the course content/syllabus, scheme of examinations etc. The convener of the Board of Examiners should ensure such matters.

(iv) **The question papers set by a Board of Examiners must be moderated by the Moderation Committee at the department level.**

(v) Following technical specifications should be strictly adhere to while setting the question papers:

(a)	Font (in English)	-	Times New Roman
(b)	Font (in Hindi)	-	unicode / krutidev
(c)	Font size	-	12
(d)	Space	-	Single Space
(e)	Paper size	-	Standard A4 size
(f)	Printing	-	On one side of the page
(g)	Certification/ Authentication	-	On the back of each page

(vi) A standard format for the first page of question paper is enclosed for ready reference as Appendix-II. However, instructions to the examinee relating to the structure of the question paper has to be specified at the time of setting of question papers by the Board of Examiners based on the syllabus and scheme of examination prescribed for the subject / paper like use of calculator, graph paper, log tables etc.

(vii) Utmost care should be given to ensure that name and identity of the Board of Examiners are not disclosed as it is strictly confidential to facilitate free & fair conduct of examination.

(viii) Translation is required to be carried out wherever needed. Each set of question paper, either in English or bilingual (English and Hindi) is to be packed in a separate sealed envelope alongwith a soft copy of the entire content of that corresponding set of Question Paper in Microsoft Word Format in the form of a CD.**Please note that hand written scanned copy of the question papers will not be accepted under any circumstances.**

(ix) There will be separate envelopes- for each set of question paper and it's CD. Theseenvelopes should be signed and sealed separately and put inside a larger envelope and signed and sealed again by the Board of Examiners. The envelopes must be superscribed with the following details :

(a) Name of the Department

(b) Name of the Course

(c) Name of the Paper

(d) Semester

(e) Unique Paper Code

Such sealed packet should be handed over to the Head of the Department by the convener of the Board of Examiners immediately on completion of the exercise. The Board of Examiners would be entirely responsible for this exercise.

10. You would be required to submit the remuneration bill for the members of the Board of Examiners to the Head of Department. Necessary proforma for settlement of claim/settlement of advance alongwith guidelines of remuneration payable to the teachers in this regard is enclosed herewith for appropriate usage Appendix-III. However, conveyance charges for maximum 03 visits would be allowed to the Examiner / convener per paper.

11. Matters relating to South Delhi Campus should be taken up with the Deputy Registrar, Examinations (South Delhi Campus) as such matters are separately dealt by the Examination Office of the South Delhi Campus.

12. The last date of submission of the question papers is March 19, 2019. It should be ensured that the question paper reaches the Head of the Department by the stipulated date to ensure timely conduct of the examination under reference.

13. It will be highly appreciated if you kindly go through the entire contents of this letter and ensure that the procedure mentioned overleaf and above is scrupulously adhered to.

14. List of papers for which question papers have to be set, schedule of remuneration for such work alongwith various proforma / envelope etc. as mentioned in the body of the letter is enclosed for appropriate usage.

Yours faithfully,

(Head of the Department)

Encl.: As above

Copy to:

1. ____________________________, Examiner I

2. ____________________________, Examiner II

3. ____________________________, Examiner III (if any)

Appendix-II

Format of the First page of a Model Question Paper in A4 size page

Unique Paper Code	:	
Name of the Paper	:	
Name of the Course	:	
Semester	:	
Duration	:	_______ hours
Maximum Marks	:	_______ Marks

Instructions for Candidates

UNIVERSITY OF DELHI

EXAMINATION – I / II

CHECK-LIST FOR CONVENER

S.No.	Type of Item	Quantity	Remarks Yes / No
1.	Letter of Appointment of Convener from the HOD	01	
2.	Copy of Undertaking of the examiners / paper setters to be submitted to the Head of the Department (Appendix-I) .	04	Yes
3.	Format of First Page of Question Paper for essential details (Appendix-II).	03	Yes
4.	Remuneration claim form for examiners / paper setters (Appendix-III)	03	Yes
5.	Envelops along with proper superscription of details of Unique Paper Code etc. for each set of question paper to be set (a &b as the case may be) size of [10"x12"].	02 / 04	Yes
6.	CD covers along with CD's for each paper. CD cover should mention Set-A & Set-B along with details of Unique Paper Code etc.	02 / 04	Yes
7.	Envelope along with proper superscription of details of Unique Paper Code etc. in which all the set of the question papers is to be put by the convener and sent to the Head of the Department confidentially. [12"x16"]	01	Yes
8.	Envelope for enclosing remuneration claim bills	02 / 04	Yes

Annexure-III

University of Delhi

(To be filled up by the Head of the Department
and returned to the Examination Office within 10 days of the receipt of the latter)

*I have not found any incompleteness (such as any missing papers etc.) or any inaccuracy in the details of papers to be set by the Department as provided by the Examination Office of the University in Annexure I.

OR

*I have found the following discrepancies in the details provided by the Examination Office of the University in Annexure - I. Kindly make the necessary corrections in the details of the papers to be set by the Department which is as follows. (Attach extra sheets, if necessary)

*Strike out whichever is not applicable

Head of the Department

Department of ________
____

Dean - Examinations

Gmail

Neeraj Sahay <neeraj.sahay1@gmail.com>

Core Course Paper Revisions-BA Programme-History of India 1) till 300 CE & 2) 300-1200 CE

Neeraj Sahay <neeraj.sahay1@gmail.com> Fri, May 31, 2019 at 7:55 PM
To: historydepartment department <historydepartment2011@gmail.com>

Dear Sir,

Thanks for your mail. Will discuss among colleagues and do the needful. I understand that time is short and we have to do it in a proper format, within the given deadline.

Regards,
Neeraj

Sent from my iPhone

On 31-May-2019, at 5:47 PM, historydepartment department <historydepartment2011@gmail.com> wrote:

> Thank you for getting back Dr. Singh. I am grateful to Dr. Sahay for accepting the role of convener. Neeraj, time is short and you might need help. Since Naina is unwell and also unavailable please confer amongst colleagues and coopt permanent faculty as you think necessary. The deadlines that we are working with are sadly not negotiable.
>
> Best.
> Sunil
>
> On Fri, May 31, 2019 at 5:27 PM O P Singh <opsingh1968@gmail.com> wrote:
>
> > Dear Sir!
> > Due to my unfamiliarity with B A Program paper and being extremely preoccupied with various other things I may not be able to be a convenor of this paper. Kindly replace me with Dr. Neeraj Sahay. However, I may be available to advise on LOCF guidelines as a resource person.
> > Regards.
> >
> > On Fri, 31 May 2019 at 4:50 PM, historydepartment department <historydepartment2011@gmail.com> wrote:
> >
> > > Thank you for letting me know Naina. Please look after yourself and get well; that has priority. We'll find an alternative convener since this is a very time-bound and important exercise.
> > >
> > > All best.
> > > Sunil
> > >
> > > On Fri, May 31, 2019 at 4:30 PM Naina Dayal <dayalnaina@gmail.com> wrote:
> > >
> > > > Dear Professor Kumar,
> > > >
> > > > I have not been at all well this week, and will not be in Delhi next week. I will not have easy access to the internet next week, but can certainly help after the 9th.
> > > >
> > > > With best wishes,
> > > > Naina
> > > >
> > > > On Fri, 31 May 2019, 16:21 historydepartment department, <historydepartment2011@gmail.com> wrote:
> > > >
> > > > > Dear Colleagues,
> > > > >
> > > > > Apologies for the delay in getting back to you regarding the revision of Core Courses. I am writing to all of you since you are (and have been in the past) associated with the teaching/examination of this/these paper(s) and/or with the preceding course revisions exercise.
> > > > >
> > > > > I am afraid we have very, very little time available to us and can hardly be ambitious with our exercise. But since these are recently revised Core Papers where we cannot intervene too

broadly anyway, our agenda is limited to the following:
1) Pruning sub-rubrics with the intention to balance course content and teaching;
2) Adding such details urgently missing;
3) Pruning our reading lists particularly under 'essential' and reordering then according to the course units/rubrics with a brief statement (in one sentence; never more than two) of what the unit/rubric will teach (the teaching outcome) and how much time in weeks would be devoted to the teaching of this unit.

Please keep the 30% limit in mind as you prune or add to sub-rubrics (please note -- that is one reason I do not mention 'rubrics'). Fix only the most grievous/urgent of problems since we would be very close to the permissible 30% limit allowed for revisions already. Drafting the teaching outcome of the unit and pruning reading lists to fix the units/rubrics should help us visit our current syllabus and mark out areas where intervention is necessary.

We have to accomplish this task by 7th June and finalise the revisions during the GBM on the 10th. The BRS of the Social Sciences is meeting on the 10th as well. They will hold another meeting, hopefully, on the 12th, giving us the minimal time necessary to get the final version of our courses in order.

It is likely that some of you will not be in Delhi between now and the 7th, but I would appreciate if you kept in touch and let your colleagues have the benefit of your insights. Since time is extremely short, I am requesting Dr. Naina Dayal, Dr. Nagendra and Dr. O.P. Singh to be the conveners of the Core Course Committee. Between them there is considerable familiarity with the teaching and examination of this paper. So that the revisions coincide with the demands of the LOCF and the mode by which the University requires the reorganised rubric-wise teaching outcomes and reading lists, I am requesting all coordinators to seek the help of Dr. O.P. Singh should they require such a resource person. Kindly divide the work amongst yourselves and please be sure to include any permanent teacher who wishes to be a part of this exercise -- the colleagues copied into this mail do not comprise an exclusive listing.

The composite BA Programme course curriculum as a word document is attached below. Please use this document for all revision purposes.

With my warm regards.
Sunil

--
Head, Department of History
Social Sciences Building
University of Delhi, Delhi 110007

--
Head, Department of History
Social Sciences Building
University of Delhi, Delhi 110007
--
O P Singh

--
Head, Department of History
Social Sciences Building
University of Delhi, Delhi 110007

Gmail

Neeraj Sahay <neeraj.sahay1@gmail.com>

BA Programme core Courses I & II Revision

Neeraj Sahay <neeraj.sahay1@gmail.com> Sat, Jun 8, 2019 at 1:28 PM
To: historydepartment department <historydepartment2011@gmail.com>, Sunil Kumar <sunilkumar.history.du@gmail.com>

Dear Sir,

PFA the revised drafts of BA Programme Courses I & II

Best Regards,

Nagendra Sharma
Neeraj Sahay

2 attachments

BA Prog Core Course I Revision.docx
36K

BA Prog Core Course II Revision.docx
28K

Gmail

Neeraj Sahay <neeraj.sahay1@gmail.com>

Core Course Revisions-History of India I and II

historydepartment department <historydepartment2011@gmail.com> Fri, May 31, 2019 at 9:58 AM
To: Neeraj Sahay Ancient <neeraj.sahay1@gmail.com>, Shobhika Mukul Ancient <shobhika.mukul@gmail.com>, Vinita Malik <malikvinita@yahoo.co.in>, Vishwamohan Jha <vishwamohanjha@gmail.com>, Shabnam <shabnam_suri@yahoo.com>, smita sahgal <smitasahgal16@yahoo.com>, "Dr. Alka Saikia" <alkasaikia@gmail.com>, Mihir Kumar Jha ARSD College <mihirjha371@gmail.com>, Vikram Chaudhary <vikramchaudhary30@gmail.com>, Naina Dayal <dayalnaina@gmail.com>, "O.P. Singh" <opsingh1968@gmail.com>, "Ranjan Anand ZHC (Eve.)" <ranjananand48@gmail.com>, Snigdha Singh <Snigdha.Singh@mirandahouse.ac.in>

Dear Colleagues,

Apologies for the delay in getting back to you regarding the revision of Core Courses. I am writing to all of you since you are (and have been in the past) associated with the examination of these two papers and/or with the preceding course revisions exercise and are therefore most familiar with these papers.

I am afraid we have very, very little time available to us (and it is possible that many teachers would be away at this juncture). But since these are recently revised Core Papers where we cannot intervene too broadly, our agenda is limited to the following:
1) Pruning sub-rubrics with the intention to balance course content and teaching;
2) Adding such details urgently missing;
3) Pruning our reading lists particularly under 'essential' and reordering then according to the course units/rubrics with a brief statement (in one sentence; never more than two) of what the unit/rubric will teach (the teaching outcome) and how much time in weeks would be devoted to the teaching of this unit.

Please keep the 30% limit in mind as you prune or add to sub-rubrics (please note -- that is one reason I do not mention 'rubrics'). Fix only the most grievous/urgent of problems since we would be very close to the permissible 30% limit allowed for revisions already. Drafting the teaching outcome of the unit and pruning reading lists to fix the units/rubrics should help us visit our current syllabus and mark out areas where intervention is necessary.

We have to accomplish this task by 7th June and finalise the revisions during the GBM on the 10th. The BRS of the Social Sciences is meeting on the 10th as well. They will hold another meeting, hopefully, on the 12th, giving us the minimal time necessary to get the final version of our courses in order.

It is likely that some of you will not be in Delhi between now and the 7th, but I would appreciate if you kept in touch and let your colleagues have the benefit of your insights. Since time is extremely short, I am requesting Dr. O.P. Singh and Dr. Ranjan Anand to be the conveners of the Core Course Committee because they are the most familiar with the demands of the LOCF and the mode by which the University requires the reorganised rubric-wise teaching outcomes and reading lists. Please be sure to include any permanent teacher that wishes to be a part of this exercise -- the colleagues copied into this mail do not comprise an exclusive listing.

The composite BA Honours course curriculum as a word document is attached below. Please use this document for all revision purposes.

With my warm regards.
Sunil

--
Head, Department of History
Social Sciences Building
University of Delhi, Delhi 110007

BA Honours 2019-UGC LOCF Course Revisions.docx
372K

Gmail

Neeraj Sahay <neeraj.sahay1@gmail.com>

Core Course Revisions-History of India I and II

Ranjan Anand <ranjananand48@gmail.com> Sat, Jun 8, 2019 at 1:05 PM
To: historydepartment department <historydepartment2011@gmail.com>
Cc: Neeraj Sahay Ancient <neeraj.sahay1@gmail.com>, Shobhika Mukul Ancient <shobhika.mukul@gmail.com>, Vinita Malik <malikvinita@yahoo.co.in>, Vishwamohan Jha <vishwamohanjha@gmail.com>, Shabnam <shabnam_suri@yahoo.com>, smita sahgal <smitasahgal16@yahoo.com>, "Dr. Alka Saikia" <alkasaikia@gmail.com>, Mihir Kumar Jha ARSD College <mihirjha371@gmail.com>, Vikram Chaudhary <vikramchaudhary30@gmail.com>, Naina Dayal <dayalnaina@gmail.com>, "O.P. Singh" <opsingh1968@gmail.com>, Snigdha Singh <Snigdha.Singh@mirandahouse.ac.in>

Dear Sir
Kindly find attached two files of revised draft syllabuses of History of India I and II. We had a meeting of the colleagues on 07.06.2019 at Dyal Singh College Evaluation Centre. A few detailed comments were also mailed to us. We have made some changes in the existing syllabus based on those suggestions.

With regards
O. P. Singh
Ranjan Anand.
[Quoted text hidden]
[Quoted text hidden]

---

2 attachments

History of India I.docx
26K

History of India II.docx
30K

DEPARTMENT OF HISTORY
UNIVERSITY OF DELHI
DELHI – 110007.
Phone No. 011-27666659

Ref. No. FASS/History/2018

Dated: 15th Oct., 2018

To
The Member of Board of Examiners
Paper Code 12311101, 12311102, 12311103
PaperTitle History of India - I

B.A./B.~~Com/B.Sc.~~ (H)(~~Prog.~~) CBCS
Semester I
Nov./Dec. 2018

Dear Dr. Neeraj Sahay,

You have been appointed as member of the Board of Examiners for the above paper. The Convener of the Board, Dr. Ranjan Anand, has been requested to convene a meeting of the Board and set the question papers by 31.10.2018 as per direction from the University. The Contact no of the convener is 9868009157.

Thanking you.

Yours Sincerely

Professor Sunil Kumar
Head of the Department

DEPARTMENT OF HISTORY
UNIVERSITY OF DELHI
DELHI – 110007.
Phone No. 011-27666659

Ref. No. FASS/History/2019

Dated: 14th March, 2019

To
The Member of Board of Examiners
Paper Code 12311202, 231201, 12311203, 2312301, 2312401
PaperTitle History of India-II (OCF), History of India-II
History of India-II (NC), History of India-I (upto c.300 B.C.E.),
History of India-II (c. 300 B.C.E. to eigth Century A.D.
B.A./~~B.Com/B.Sc.~~ (H)~~(Prog.)~~
Semester/~~Annual~~ - II
May/June 2019

Dear Dr. Neeraj Sahay,

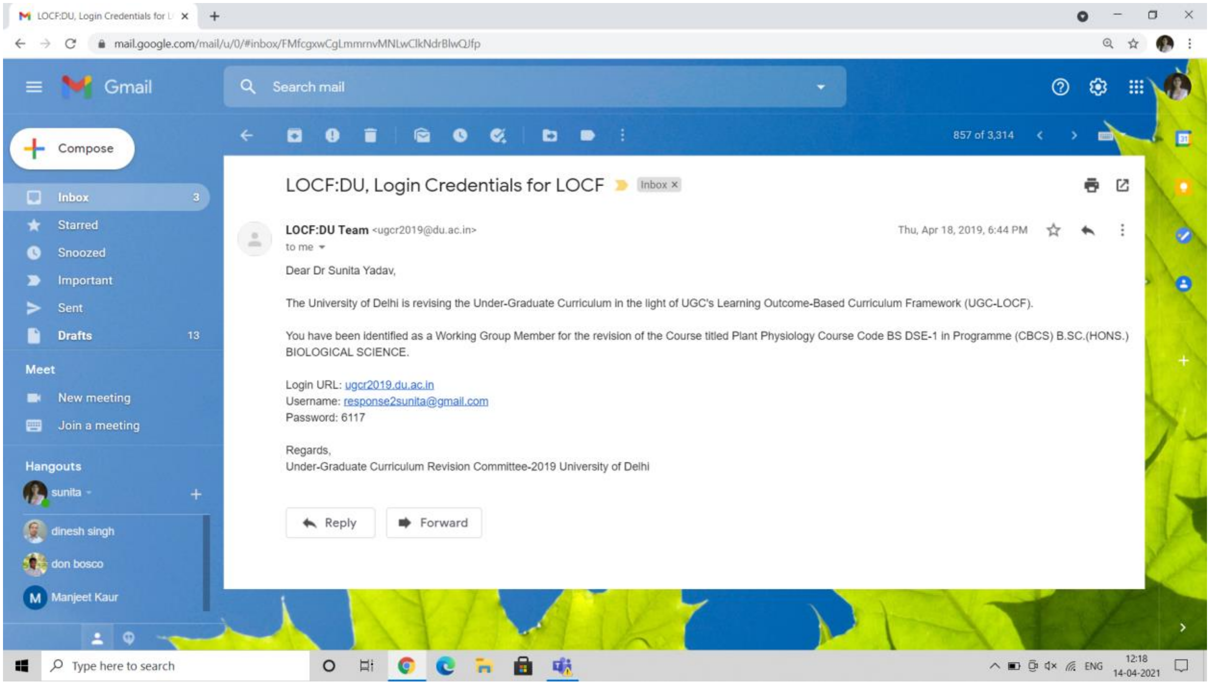
You have been appointed as member of the Board of Examiners for the above paper. The Convener of the Board, Dr. Ranjan Anand, has been requested to convene a meeting of the Board and set the question papers by 02.04.2019 as per direction from the University. The Contact no of the convener is 9868009157.

Thanking you,

Yours Sincerely

Professor Sunil Kumar
Head of the Department

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING



To

Bot/18/09
24.10.2018

Dr. Rekha Kathal
The Convener,
Daulat Ram College
4, Patel Marg,
University of Delhi
Delhi - 110007

Subject: Request for setting of question papers by the Board of Examiners (paper setters) **for forthcoming Undergraduate Three Year CBCS Semester- I / III / V Examinations, Nov / Dec - 2018 for the Academic Year2018-19- regarding**

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

1.	Examiner	: Dr. Rekha Kathal, DRC (9811356428) (Convener)
2.	Examiner	: Dr. Tabassum Afshan, SVC (9711798386)
3.	Examiner	: Dr. Parveen Garg, SSNC (9811226923)
4.	Examiner (If any)	: ________________

3. This Board of Examiners would be responsible for setting of question papers as per following details:

a) Name of Course : Botany

b) Semester : III

c) Name of the Paper: Ethnobotany

d) Unique Paper Code: 32163301

e) Medium of setting the Question paper: English / English & Hindi Language

4. It would be the responsibility of the Convener to ensure that the paper is set as per the syllabus and the scheme of examination. The syllabus and the schemes of examination is available on the University of Delhi website and / or may be obtained from the Department concerned.

5. The three schemes of Undergraduate examination viz. ***three year semester mode, erstwhile FYUP Semester modeand examination for new UG admission having CBCS scheme are being held simultaneously,*** therefore the boards of examiners are required to be instructed to set question papers distinguishing clearly the mode for which paper setting is to be done as per Unique Paper Code alongwith relevant course content / syllabus, scheme of examinations, number of question papers required etc.

6. The board of examiners shall ensure the compliance of relevant guidelines for PWD candidates, wherever applicable. Para XV of the notification dated 28/01/2014 in this regard is reproduced below :-

"Alternative objective questions in lieu of descriptive questions should be provided for Hearing-Impaired persons, in additional to the existing policy of giving alternative questions in lieu of questions requiring visual inputs, for persons with Visual Impairment."

Ref No. - SVC/PREX/Nov, 2018

To
Dr. Neeti Mehla
Dept. of Botany
SVC
N. Delhi - 21

Dated:- 1/11/18

Dear Sir/Madam

This Is to inform you that the Sri Venkateswara College authorities have appointed the following teachers as joint examiners to conduct the practical examination in paper CC- 12 entitled Plant Physiology of B.Sc. (Hons.) / B.Sc. Prog. ~~(Life Science)~~ Semester I, III, V, Practical Examinations, in November, 2018 at Sri Venkateswara College.

Code	Internal Examiner	Code	External Examiner
5180203	Dr. Neeti Mehla	5180204	Dr. Malti Gupta

Marks:

Duration 3 **Hrs.**

Time: 9:30AM - 12:30 PM

Date of Exam 14.11.18

This is further informed that according to the decision taken by the university for conducting the practical examinations on Sundays or holidays or during vacation, the teachers are entitled to claim conveyance charges from the place of residence to the place of examination and back irrespective of whether the examination is held at the place of duty or at a place other than the place of duty.

The question will be set by the examiners concerned on the spot.

The department concerned will notify, through the Principal of the college concerned, such guidelines to the examiners as may be necessary to ensure that the uniformity of the standard is being mentioned in setting the questions of the practical examination.

I, therefore, request you to kindly confirm your acceptance to the undersigned on the enclosed form, **IMMEDIATELY** after the receipt of the appointment letter. Change of address, if any, along with telephone no. may kindly be intimated to the undersigned.

You are requested not to accept the examinership In case any of your nearrelations(wife,husband,son,daughter,brother,sisiter,nephew,niece,sister-in-law,brother-in-law,daughter-in-law and son-in-law) is a candidate for this examination.

You are particularly requested to treat the matter dealt within this letter as **STRICTLY CONFIDENTIAL**. The University takes great care not to discuss the name of the examiners.

I am sure you will kindly extend your help and cooperation.

You may contact the Superintendent for practical examinations for any information, if necessary at ____________
Yours Faithfully

PRINCIPAL
Sri Venkateswara College
Dhaula Kuan, New Delhi – 110 021

1/11/18
SUPERINTENDENT
Annual Practical Examination
★ Dept. of Botany ★
Sri Venkateswara College
Dhaula Kuan New Delhi

Scanned with CamScanner

(31)

No. ____________
Date: ____________

To

Dr. Anita Verma
The Convener/ ~~Examiner,~~
SVC
University of Delhi

Subject: Request for setting of question papers by the Board of Examiners (paper setters) for the following forthcoming Undergraduate Examination to be held in May / June 2020 for the Academic Year 2019-20 :-

(i) **Three year Semester Examination – ~~II~~/ IV ~~/ VI~~**
(ii) **Erstwhile FYUP Semester Examination – IV / VI / VIII**

Sir/Madam,

1. This is to state that question papers for the above mentioned forthcoming Under Graduate Courses are required to be set in line with the Executive Council Resolution No. 05 dated 01/05/2003. The said E.C. Resolution is reproduced below:-

   "Examination and evaluation / revaluation work be mandatory for all College and University teachers and, as far as possible, question papers be set by a Board of Examiners. Appointment of Head Examiner/Additional Examiners be rotated on the basis of seniority from amongst the teachers who are teaching the concerned course".

2. The Board of Examiners consisted of the following teachers is constituted where you will be acting as the Convener / Examiner.

1.	Examiner	:	Dr. Anita Verma (Convener)	SVC- 9818311447
2.	Examiner	:	Dr. Anju Jain	DRC- 9868834721
3.	Examiner	:	Dr. Jitendra	Shivaji - 9953585599
4.	Examiner (If any)	:		

3. This Board of Examiners would be responsible for setting of question papers as per following details:

a) Name of Course : B. Sc. (H)

b) Semester : IV (3YUG)

c) Name of the Paper: Animal Physiology and Functional Histology - II

d) Unique Paper Code: 223401, ZOHT- 405

e) Medium of setting the Question paper: English / English & Hindi Language

4. It would be the responsibility of the Convener to ensure that the paper is set as per the syllabus and the scheme of examination. The syllabus and the schemes of examination is available on the University of Delhi website and / or may be obtained from the Department concerned.

5. The three schemes of Undergraduate examination viz. ***three year semester mode, erstwhile FYUP Semester modeand examination for new UG admission having CBCS scheme are being held simultaneously,*** therefore the boards of examiners are required to be instructed to set question papers distinguishing clearly the mode for which paper setting is to be done as per Unique Paper Code alongwith relevant course content / syllabus, scheme of examinations, number of question papers required etc.

6. The board of examiners shall ensure the compliance of relevant guidelines for PWD candidates, wherever applicable. Para XV of the notification dated 28/01/2014 in this regard is reproduced below :-

"Alternative objective questions in lieu of descriptive questions should be provided for Hearing-Impaired persons, in additional to the existing policy of giving alternative questions in lieu of questions requiring visual inputs, for persons with Visual Impairment."

Annexure-III

University of Delhi

(To be filled up by the Head of the Department
and returned to the Examination Office within 10 days of the receipt of the latter)

*I have not found any incompleteness (such as any missing papers etc.) or any inaccuracy in the details of papers to be set by the Department as provided by the Examination Office of the University in Annexure I.

OR

*I have found the following discrepancies in the details provided by the Examination Office of the University in Annexure - I. Kindly make the necessary corrections in the details of the papers to be set by the Department which is as follows. (Attach extra sheets, if necessary)

*Strike out whichever is not applicable

Head of the Department
Vimes

Department of विभागाध्यक्ष / H
प्राणी विज्ञान विभाग / Departn
दिल्ली विश्वविद्यालय / Unive
दिल्ली-110007 / Delhi-1

Dean - Examinations

Annexure - I

Biological Sciences
Sri Venkateswara College
(University of Delhi)

Ref. No. SVC/Syllabus rev./BS/2019/Core Papers-1 26th March, 2019

B.Sc. (Hons.) Biological Sciences (CBCS)

S.No.	Name of the paper	Paper code	Paper Coordinator	Working Committee Members	Email & Mobile Number
1	Semester I (CBCS) BS C1	Chemistry (Unique Code No. **31071101**)	Dr Vibha Saxena vibhasaxena.svc@gmail.com 98102 17094	Dr Sanjay Batra Dr Sharada Pasricha Dr. Pooja	skbatra20@gmail.com 9891064490 spasricha@svc.ac.in 9971099180 Pooja.chem123@gmail.com 9582462939
2	Semester I (CBCS) BS C2	Light and Life (Unique Code No. **31071102**)	Dr Anita Verma dranitaverma@svc.ac.in 9818311447	Dr Rajendra Phartyal Dr Aditi Kothari Dr Pamil Tayal	r.phartyal@gmail.com 99 999 17 155 aditikoth@gmail.com 9810336240 pamiltayal@gmail.com 9810091294
3	Semester II (CBCS) BS C3	Biophysics (Unique Code No. 31071202)	Dr Anunay Chaudhary anunay_physics@yahoo.co.uk 9654646534	Dr Anant Pandey Dr Ravindra Varma Dr Kameshwar Sharma YVR	apandey@svc.ac.in 9811720585 ravindra@svc.ac.in 8373912916 kameshwar@svc.ac.in 9910374426
4	Semester II (CBCS) BS C4	Biodiversity (Unique Code No. 31071201)	Dr Kalyani Krishna kalyani30jun @ gmail.com 9810637363	Dr Sunila Khurana Dr Pooja Gokhale Dr P Jayaraj	sunilakhurana57@gmail.com 9871985398 gokhale_20@hotmail.com 9999747375 jayaraj@svc.ac.in 9650472057

Meenakshi
Dr. Meenakshi Kuhar
Coordinator, Biological Science Syllabus Revision

Dr. P. Hemalatha Reddy
Principal

5	Semester III (CBCS) BS C5	Proteins and Enzymes (Unique Code No. 31071301)	Dr Meenakshi Kuhar mkuhar@rediffmail.com 9818278545	Dr Kameshwar Sharma YVR Dr Ravindra Varma Dr Sarika Yadav	kameshwar@svc.ac.in 9910374426 ravindra@svc.ac.in 8373912916 Reachtosarika27@gmail.com 8527301091
6	Semester III (CBCS) BS C6	Cell Biology (Unique Code No. 31071302)	Dr P Hemalatha Reddy principal@svc.ac.in 9711796886	Dr Amit Vashistha Dr Mansi Verma Dr Nitika Kaushal	vashishtha24@svc.ac.in 8860302550 mansiverma20@gmail.com 9899916229 nitikakaushal3@gmail.com 9810302719
7	Semester III (CBCS) BS C7	Ecology (Unique Code No. 31071303)	Dr Vartika Mathur vmathur@svc.ac.in 9810386575	Dr Rajendra Phartyal Dr Pooja Gokhale Dr Pamil Tayal	r.phartyal@gmail.com 99 999 17 155 gokhale_20@hotmail.com 9999747375 pamiltayal@gmail.com 9810091294
8	Semester IV (CBCS) BS C8	Systems Physiology (Unique Code No. 31071401)	Dr Anita Verma dranitaverma@svc.ac.in 9818311447	Dr P Jayaraj Dr Rajendra Phartyal Dr. Richa Mishra	jayaraj@svc.ac.in 9650472057 r.phartyal@gmail.com 99 999 17 155 richamisra@svc.ac.in 9811971403
9	Semester IV (CBCS) BS C9	Molecular Biology (Unique Code No. 31071402)	Dr Meenkashi Kuhar mkuhar@rediffmail.com 9818278545	Dr Amit Vashistha Dr Mansi Verma Dr Vandana Malhotra	vashishtha24@svc.ac.in 8860302550 mansiverma20@gmail.com 9899916229 vmal71@gmail.com 9910466006
10	Semester IV (CBCS) BS C10	Metabolism and Integration (Unique Code No. 31071403)	Dr Nandita Narayansamy nnarayanasamy@svc.ac.in 9810400139	Dr Kameshwar Sharma YVR Dr Nitika Kaushal Dr Nimisha Sinha	kameshwar@svc.ac.in 9910374426 nitikakaushal3@gmail.com 9810302719 nimishasinha@svc.ac.in 9350741848

Meenakshi

Dr. Meenakshi Kuhar
Coordinator, Biological Science Syllabus Revision

Dr. P. Hemalatha Reddy
Principal

11	Semester V (CBCS) BS C11	Growth and Reproduction (Unique Code No. 31071501)	Dr Anita Verma dranitaverma@svc.ac.in 9818311447	Dr Kalyani Krishna Dr Jayaraj Dr Vagisha Rawal	kalyani30jun @ gmail.com 9810637363 jayaraj@svc.ac.in 9650472057 rvagisha@gmail.com 9990647363
12	Semester V (CBCS) BS C12	Genetics (Unique Code No. 31071502)	Dr Nandita Narayansamy nnarayanasamy@svc.ac .in 9810400139	Dr Shalini Sen Dr Ravindra Varma Dr Meeta Bharadwaj	ssen@svc.ac.in 9810677630 ravindra@svc.ac.in 8373912916 bhardwajmeeta.svc@gmail.co m 9958147779
13	Semester VI (CBCS) BS C13	Immunobiology (Unique Code No. 31071601)	Dr Anju Kaicker anjukaicker@yahoo.co. in 9810887011	Dr Nandita Narayansamy Dr. Nitika Kaushal Dr Aditi Kothari	nnarayanasamy@svc.ac.in 9810400139 nitikakaushal3@gmail.com 9810302719 aditikoth@gmail.com 9810336240
14	Semester VI (CBCS) BS C14	Evolutionary Biology (Unique Code No. 31071602)	Dr Anita Verma dranitaverma@svc.ac.in 9818311447	Dr Rajendra Dr P Jayaraj Dr Vagisha Rawal	r.phartyal@gmail.com 99 999 17 155 jayaraj@svc.ac.in 9650472057 rvagisha@gmail.com 9990647363

Meenakshi

Dr. Meenakshi Kuhar
Coordinator
Biological Sciences Syllabus Revision

Dr. P. Hemalatha Reddy
Principal

Biological Sciences
Sri Venkateswara College
(University of Delhi)

Ref. No. SVC/Syllabus rev./BS/2019/SEC Papers-1 26th March, 2019

B.Sc. (Hons.) Biological Sciences (CBCS)

S No	Name of the paper (SEC)	Coordinator	Working Committee Members
1	Medicinal Botany (BS SEC-1)	Dr Shukla Saluja	Dr Neeti Mehla Dr Tabassum Afshan Dr Neer K Singh
2	Medical Diagnostics (BS SEC-2)	Dr Om Prakash	Dr Richa Mishra Dr Riyaaz Bakshi Dr Preeti Kandelwal
3	Bioinformatics (BS SEC-3)	Dr N Latha	Dr Kameshwar Sharma YVR Dr Amit Vashishth Dr Mansi Verma
4	Organic farming (BS SEC-4)	Dr Kalyani Krishna	Dr Amit Vashishth Dr Yogender Gautam Dr Pamil Tayal
5	Public Health Management (BS SEC-5)	Dr Om Prakash	Dr Namita Nayar Dr Vagisha Rawal Dr Arti Sehrawat
6	Biochemical Techniques (BS SEC-6)	Dr Meenakshi Kuhar	Dr Anju Kaicker Dr Kameshwar Sharma YVR Dr Ravinder Verma

Meenakshi

Dr. Meenakshi Kuhar
Coordinator
Syllabus Revision committee

Dr. P. Hemalatha Reddy
Principal
Sri Venkateswara College

Biological Sciences
Sri Venkateswara College
(University of Delhi)

Ref. No. SVC/Syllabus rev./BS/2019/DSE Papers-1

26th March, 2019

B.Sc. (Hons.) Biological Sciences (CBCS)

S No	Name of the paper	Paper Coordinator	Working Committee Members
1	Plant Physiology (BS DSE-1)	Dr Kalyani Krishna	Dr Kameshwar Sharma YVR Dr Sunita Yadav Dr Neer K Singh
2	Animal Behavior and Chronobiology (BS DSE-2)	Dr Vartika Mathur	Dr Richa Mishra Dr Vagisha Rawal Dr Arti Sehrawat
3	Biotechnology (BS DSE-3)	Dr Shalini Sen	Dr Kameshwar Sharma YVR Dr. Nimisha Sinha Dr Vandana Malhotra Dr Nitika Kaushal
4	Endocrinology (BS DSE-4)	Dr Nandita Narayansamy	Dr Anju Kaicker Dr Jayaraj Dr Namita Nayar
5	Natural Resource Management (BS DSE-5)	Dr Sunila Khurana	Dr Pooja Gokhale Dr Yogender Gautam Dr Neer K Singh
6	Wild Life and Conservation (BS DSE-6)	Dr Vartika Mathur	Dr Namita Nayar Dr Arti Sehrawat Dr Sadqua Shamim
7	Nutritional Biochemistry (BS DSE-7)	Dr Nandita Narayansamy	Dr N Latha Dr Kameshwar Sharma YVR Dr Meeta Bhardwaj
8	Microbiology (BS DSE-8)	Dr Shalini Sen	Dr Kameshwar Sharma YVR Dr Nitika Kaushal Dr Meeta Bhardwaj

Meenakshi

Dr. Meenakshi Kuhar
Coordinator
Syllabus Revision committee

Dr. P. Hemalatha Reddy
Principal
Sri Venkateswara College

Choice Based Credit System (CBCS)

UNIVERSITY OF DELHI

DEPARTMENT OF STATISTICS

Learning Outcomes-based Curriculum Framework (LOCF)

of

BACHELOR OF SCIENCE (HONS.) IN STATISTICS
(B.Sc. (Hons.) Statistics)
(Effective from Academic Year 2019-20)

PROPOSED SYLLABUS

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2019 and

Executive Council on YYYY, 2019

Contents

1. Introduction to Programme

B.Sc. (Hons.) Statistics is a three-year undergraduate program with specialization in statistics. The programme fosters interdisciplinary approach to the study of Statistics, Mathematics, and Computers aiming to promote holistic education useful in handling social, economics, engineering, physical and bio-sciences problems. The curriculum is dispensed using a combination of classroom teaching, project-based learning, practical's, group discussions, presentations, home assignments, industry interactions and exposure, internships and fieldwork. The programme has a unique and innovative course structure which engenders creative out of the box thinking.

1.1 Eligibility for Admissions

As per admission bulletin for under-graduate programme of University of Delhi.

2. Introduction to CBCS (Choice Based Credit System)

Scope:

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on students' performance in examinations enables the student to move across institutions of higher learning. The uniformity in evaluation system also enable the potential employers in assessing the performance of the candidates.

Definitions:

(i). 'Academic Programme' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/Centre.

(ii). 'Course' means a segment of a subject that is part of an Academic Programme.

(iii). 'Programme Structure' means a list of courses (Core, Elective, Open Elective) that makes up an Academic Programme, specifying the syllabus, Credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University Rules, eligibility criteria for admission.

(iv). 'Core Course' means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course.

(v). 'Elective Course' means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre.

(vi). 'Discipline Specific Elective' (DSE) course is the domain specific elective course offered by the main discipline/subject of study. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature also, but these are needed to be offered by main discipline/subject of study.

(vii). 'Dissertation/Project' is an elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member. Project work/Dissertation is considered as a special course involving application of knowledge in solving / analysing / exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

(viii). 'Generic Elective' (GE) course is an elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure to other disciplines. A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

(ix). 'Ability Enhancement Courses' (AEC) also referred as Competency Improvement Courses/Skill Development Courses/Foundation Course. The Ability Enhancement Courses (AEC) may be of two kinds: AE Compulsory Course (AECC) and AE Elective Course (AEEC).

(x). 'AECC' are the courses based upon the content that leads to Knowledge enhancement. The two AECC are: Environmental Science, English/ MIL Communication.

(xi). 'AEEC' are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc. These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction. These courses are also referred to as Skill Enhancement Courses (SEC).

(xii). 'Credit' means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 Credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course

(xiii). 'CGPA' is cumulative grade points calculated for all courses completed by the students at any point of time.

(xiv). 'SGPA' means Semester Grade Point Average calculated for individual semester.

(xv). 'CGPA' is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

(xvi). 'Grand CGPA' is calculated in the last year of the course by clubbing together of CGPA of two years, i.e., four semesters. Grand CGPA is being given in Transcript form. To benefit the student a formula for conversation of Grand CGPA into %age marks is given in the Transcript.

3. Programme Structure

The B.Sc. (Hons.) Statistics is a three year programme divided into six semesters. A student is required to complete 148 credits for the completion of programme and the award of degree.

3.1 Alignment with CBCS

The B.Sc. (Hons.) Statistics programme is aligned with CBCS structure as given in Table 1

Table 1: CBCS Course Structure for B.Sc. (Hons.) Programme

Course	***Credits**	
	Theory+ Practical	Theory + Tutorial
I. Core Course		
(14 Papers)	14X4= 56	14X5=70
Core Course Practical / Tutorial*		
(14 Papers)	14X2=28	14X1=14
II. Elective Course		
(8 Papers)		

A.1. Discipline Specific Elective	4X4=16	4X5=20
(4 Papers)		
A.2. Discipline Specific Elective		
Practical/ Tutorial*	4 X 2=8	4X1=4
(4 Papers)		
B.1. Generic Elective/		
Interdisciplinary	4X4=16	4X5=20
(4 Papers)		
B.2. Generic Elective		
Practical/ Tutorial*	4 X 2=8	4X1=4
(4 Papers)		

- Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester

III. Ability Enhancement Courses

1. **Ability Enhancement Compulsory**		
(2 Papers of 4 credit each)	2 X 4=8	2 X 4=8
Environmental Science		
English/MIL Communication		
2. **Ability Enhancement Elective** (Skill Based)		
(Minimum 2)		
(2 Papers of 4 credit each)	2 X 4=8	2 X 4=8
Total credit	**148**	**148**

Institute should evolve a system/policy about Interest/Hobby/Sports/NCC/NSS/related courses on its own.

*** Wherever there is a practical there courses will be no tutorial and vice-versa**

3.2 Details of Programme

Core Papers (Credits: 6 each) (14 papers)

STAT-C-101 Descriptive Statistics (Theory+ Practical)
STAT C-102 Calculus (Theory+ Tutorial)
STAT-C-201 Probability and Probability Distributions (Theory+ Practical)
STAT C-202 Algebra (Theory+ Practical)
STAT-C-301 Sampling Distributions (Theory+ Practical)
STAT-C-302 Survey Sampling and Indian Official Statistics (Theory+ Practical)
STAT C-303 Mathematical Analysis (Theory+ Practical)
STAT-C-401 Statistical Inference (Theory+ Practical)
STAT-C-402 Linear Models (Theory+ Practical)
STAT-C-403 Statistical Quality Control (Theory+ Practical)
STAT-C-501 Stochastic Processes and Queuing Theory (Theory+ Practical)
STAT-C-502 Statistical Computing Using C/C++ Programming (Theory+ Practical)
STAT-C-601 Design of Experiments (Theory+ Practical)
STAT-C-602 Multivariate Analysis and Nonparametric Methods (Theory+ Practical)

Discipline Specific Elective Papers (Credits: 6 each) (4 papers to be selected)

DSE-1

(A) Time Series Analysis (Theory+ Practical) or
(B) Demography and Vital Statistics (Theory+ Practical)

DSE-2

(A) Operations Research (Theory+ Practical) or
(B) Econometrics (Theory+ Practical)

DSE-3

(A) Actuarial Statistics (Theory+ Practical) or
(B) Biostatistics and Survival Analysis (Theory+ Practical)

DSE-4

(A) Financial Statistics (Theory+ Practical) or
(B) Project Work (Sixth Semester)

Skill Enhancement Courses (Credits: 4 each) (2 papers to be selected)

1. Statistical-Data Analysis Using Software Packages
2. Statistical Data Analysis Using R
3. Statistical Techniques for Research Methods
4. Statistical Simulation Techniques

Generic Elective Papers (GE) (Credits: 6 each) (to be offered to other Departments/Disciplines)

1. Statistical Methods
2. Introductory Probability

3. Basics of Statistical Inference
4. Applied Statistics

Note:

1. There will be one batch of 15 students for practical classes.
2. Each practical will carry 50 marks including 25 marks for continuous evaluation and 5 marks for the oral test.
3. Colleges are advised and encouraged to conduct at least 50% of the practicals using spreadsheet (MS Excel) or any statistical package (SPSS/R/MATLAB).
4. At least four questions have to be compulsorily attempted in the final practical examination.
5. Hardcopy of practical file has to be maintained by the students for each practical paper.

3.3 Semester-wise Placement of Courses

Table 2: Semester wise Details of B.Sc. (Hons.) Statistics Course & Credit Scheme

Year	Semester	Core Course	Ability Enhancement Compulsory Course (AEC)	Skill Enhancement Course (SEC)	Discipline Specific Elective (DSE)	Generic Elective (GE)	Semester-wise Credits
I	I	STAT-C-101: Descriptive Statistics (L+P) STAT -C-102: Calculus (L+T)	AECC 1			STAT-GE-1 (L+P)	22
	L+T/P	4+2=6; 5+1=6.	4			4+2=6	
	II	STAT-C-201: Probability and Probability Distributions (L+P) STAT -C-202: Algebra (L+P)	AECC 2			STAT-GE-2 (L+P)	22
	L+T/P	4+2=6; 4+2=6.	4			4+2=6	
II	III	STAT-C-301:Sampling Distributions (L+ P) STAT-C-302: Survey Sampling and Indian Official Statistics (L+ P) STAT-C-303: Mathematical Analysis (L+ P)		SEC (1/2/3/4) (L+P)		STAT-GE-3 (L+P)	28
	L+T/P	4+2=6; 4+2=6; 4+2=6.		2+2=4		4+2=6	
	IV	STAT-C-401: Statistical Inference (L+ P) STAT-C-402: Linear Models (L+ P) STAT-C-403: Statistical Quality Control (L+ P)		SEC (1/2/3/4) (L+P) Different from semester III option (L+P)		STAT-GE-4 (L+P)	28
	L+T/P	4+2=6; 4+2=6; 4+2=6.		2+2=4		4+2=6	

III	V	STAT-C-501: Stochastic Processes and Queuing Theory (L+ P)			DSE-1-(A/B) (L+P)		24
		STAT-C-502: Statistical Computing Using C/C++ Programming (L+ P)			DSE-2-(A/B) (L+P)		
	L+T/P	4+2=6; 4+2=6.			4+2=6; 4+2=6.		
	VI	STAT-C-601: Design of Experiments (T+ P)			DSE-3-(A/B) (L+P)		24
		STAT-C-602: Multivariate Analysis and Nonparametric Methods (T+ P)			DSE-4-(A/B) (L+P)		
	L+T/P	4+2=6; 4+2=6.			4+2=6; 4+2=6.		
III						**Total Credits**	**148**

Legend: L -Lecture Class; T =Tutorial Class; P = Practical Class
Note: One-hour lecture per week equals 1 Credit, 2 hours practical class per week equals 1 credit.

3.4 Number of Courses offered

Table 3: Number of courses offered

S. No.	Course Type	No. of Courses
1.	Core Course	14
2.	Ability Enhancement Compulsory Course (AEC)	4
3.	Skill Enhancement Course (SEC)	4
4.	Discipline Specific Elective (DSE)	8
5.	Generic Elective (GE)	4
	Total Number of Courses Offered	**34**

4. Learning Outcome Based Approach

B.Sc. (Hons.) Statistics programme is designed in such a way that students will be exposed to the real world data related to industries and society, identifying the problems and working towards their solutions through various analytical and statistical techniques. The course is designed to imbibe strong foundation of statistics in students.

5. Graduate Attributes

On completion of the programme students are expected to have acquired the skills of effective communication, critical thinking, social research methods and social outreach. The attributes expected from the graduates of B.Sc. (Hons.) Statistics are:

i. A holistic knowledge and understanding of basic concepts in statistics and its linkages with art, science and technology.
ii. The capacity to identify, understand and solve the problems of society.
iii. The ability to collect, analyse, interpret and present the data and bring out the meaning, correlations and interrelationships.
iv. Team building and leadership skills, communication, creative and critical thinking skills, and innovative problem solving skills.
v. To provide scientific approaches to develop the domain of human knowledge through the use of empirical data expressed in quantitative form.
vi. To enable the students to understand basic concepts and aspects related to research, various techniques to collect the data, analyse the data and interpret the results thereafter.
vii. Learning the basic programming languages and statistical software will help students to easily switch over to any other statistical software in future.

6. Qualification Description

Upon successfully completing the Programme the students will be conferred a degree of B.Sc. (Hons.) Statistics. It is an inter-disciplinary programme equipping the students in the knowledge of statistics. Besides, it also imparts the requisite knowledge of mathematics and statistical softwares.

7. Programme Objectives

1. To imbibe strong foundation of statistics in students.
2. To familiarize students with basic to high-level statistical concepts.
3. To update students with mathematical tools that aid in statistical theory.
4. To teach/strengthen students' knowledge of spreadsheets, programming languages and statistical packages.
5. To promote application-oriented pedagogy by exposing students to real world data.
6. To make students do projects, which prepares them for jobs/markets.

8. Programme Learning Outcomes

This course exposes the students to the beautiful world of Statistics and how it affects each and every aspect of our daily life. The course is designed to equip students with all the major concepts of Statistics along with the tools required to implement them. Introduction to computer softwares help them in analysis of data by making optimum usage of time and resources. These sofwares give them the necessary support and an edge when progressing to their professional careers. Exposure to plethora of real life data helps in honing their analytical skills. Having practical component with every paper invokes their exploratory side and fine-tunes the interpretation abilities. Such a pedagogy goes a long way in giving them the required impetus and confidence for consultancy startups/jobs in near future. The structure of the course also motivates/helps the students to pursue careers in related disciplines, especially the data sciences, financial statistics and actuarial sciences.

9. Teaching Learning Process

The faculty of the Statistics department in the constituent colleges of the University of Delhi is primarily responsible for organizing lectures for B.Sc. (Hons.) Statistics. The instructions related to tutorials and practicals are provided by the respective registering units under the overall guidance of the Department of Statistics, University of Delhi.

There shall be 90 instructional days excluding examination in a semester.
(Add details about Projects/Dissertation and role of supervisor)

Teaching Pedagogy:

Teaching pedagogy involves class room interactions, discussions, presentations, practical work based on courses, class tests and assignments.

This is detailed out for each course of the programme in section 11 under "**Facilitating the Achievement of Course Learning Outcomes**".

10. Assessment Methods/ Evaluation Scheme

The students registered for B.Sc. (Hons.) Statistics programme will study semester I to VI at the constituent colleges of the University Delhi. During these semesters Core, AECC, DSE and SEC courses are offered.

(i) English shall be the medium of instruction and examination.
(ii) Examinations shall be conducted at the end of each Semester as per the Academic

calendar notified by the University of Delhi.

(iii) The assessment broadly comprise of internal assessment and end semester examination. Each theory paper will be of 100 marks with 25% marks for internal assessment and 75% marks for end semester examination. Each practical paper will be examined out of 50 marks with 50% marks for continuous evaluation and 50% marks for end semester examination. Skill enhancement paper will be examined out of 100 marks.

10.1 Pass Percentage & Promotion Criteria:

The following provisions shall be applicable to students admitted to the B.Sc. (Hons.) Statistics programme:

a) A student who appears in an odd semester examinations or who was eligible to appear in the odd semester examinations but remains absent in any or all the papers of the said semester, shall move on to the next even semester irrespective of his/her result in the said examinations.

b) A student who has obtained 40% on the aggregate taking together all the papers in theory examination (including internal assessment) and practical examination conducted in Ist and IInd semester shall be promoted to the second academic year/IIIrd semester.

c) A student who has obtained 40% on the aggregate taking together all the papers in theory examination (including internal assessment) and practical examinations conducted in IIIrd and IVth semester shall be promoted to the third academic year/ Vth semester.

d) Students who do not fulfill the promotion criteria mentioned above shall be declared fail in the promotion examination of the academic year concerned. However, they shall have the option to retain the marks in the papers in which they want to retain.

e) If a student has secured an aggregate of minimum 40% marks taking together all the papers in theory examination (including internal assessment) and practical examination till the end of the third year, i.e., upto the end of the VIth semester, then she/he shall be awarded the degree in which the student has been admitted.

f) A student who wants to re-appear for improvement in marks in a paper prescribed for semester I/III/V may do so only in the semester examinations to be held in November/December. A student who wants to re-appear for improvement in a paper prescribed in semester II/IV/VI may do so only in the examinations to be held in May/June.

10.2 Semester to Semester Progression:

a) A student may re-appear in any theory paper prescribed for a semester, on foregoing in writing her/his previous performance in the paper/s concerned. This can be done in the odd/even semester examination only (for example , a student reappearing in paper prescribed for semester I examination may do so along with subsequent semester IIIrd examination and not along with papers for semester Vth).

b) A candidate who has cleared examinations of third academic year (Vth and VIth semesters) may re-appear in any paper of V or VI semester only once, at the odd/even examinations on foregoing in writing her/his previous performance in the paper/s concerned, within the prescribed span period. (Note: The candidate of this category will not be allowed to join any post-graduate courses).

c) In the case of re-appearance in paper, the result will be prepared on the basis of candidate's current performance in the examinations.

d) In the case of a candidate, who opts to re-appear in any paper/s under the aforesaid provisions, on surrendering her/his earlier performance but fails to reappear in the paper/s concerned, the marks previously secured by the candidate in the paper/s in which she/he has failed to re-appear shall be taken into account while determining her/his result of the examination held currently.

e) Re-appearance in practical/internal assessment shall not be allowed.

f) Duration of end semester theory examinations of Core and Elective subjects shall be three hours.

g) The entire evaluation process for AECC and Skill Enhancement Courses (SEC) shall be undertaken by each college where the AECC and SEC are being taught and the teacher responsible for the conduct of learning of the AECC and SEC shall be responsible for the evaluation.

10.3 Span Period

No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of five years from the date of admission to the Part-I/Semester-I of the B.Sc. (Hons.) Statistics Programme.

10.4 Grade Points

A student who becomes eligible for the degree shall be categorized on the basis of the combined result of semester I to semester VI examinations under CBCS on a 10 point grading system with the letter grades. Grade point table as per university examination rules.

10.5 CGPA Calculation

As per university examination rules.

10.6 SGPA Calculation

As per university examination rules.

10.7 Grand SGPA Calculation

As per university examination rules.

10.8 Conversion of Grand CGPA into Marks

As notified by competent authority the formula for conversion of Grand CGPA into marks is: Final %age of marks = CGPA based on all four semesters × 9.5.

10.9 Division of Degree into Classes

As per university examination rules.

10.10 Attendance Requirement

As per university examination rules.

10.11 Guidelines for the Award of Internal Assessment Marks B.Sc. (Hons.) Statistics Programme (Semester Wise)

As per university examination rules.

11. Course Wise Content Details for B.Sc. (Hons.) Statistics Programme

Core Papers in Statistics

Bachelor of Science (Hons.) in Statistics
Semester I
STAT-C-101: Descriptive Statistics

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include:

- To summarize the data and to obtain its salient features from the vast mass of original data.
- To understand the concept of attributes.
- To understand the concepts of probability and its applications.
- To understand the concept of random variables, probability distributions and expectation.

Course Learning Outcomes:
After completing this course, the students should have developed a clear understanding of:

- Concepts of statistical population and sample, variables and attributes.
- Tabular and graphical representation of data based on variables.
- 'Conditions for the consistency' and criteria for the independence of data based on attributes.
- Measures of central tendency, Dispersion, Skewness and Kurtosis.
- Moments and their use in studying various characteristics of data.
- Different approaches to the theory of probability.
- Important theorems on probability and their use in solving problems.
- Concept of random variables and its probability distributions.
- Concept of joint, marginal and conditional probability distribution for two dimensional random variables and their independence.
- Univariate transformation and expectation of random variables.

Contents:

UNIT 1

Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement-nominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram and Ogives, Theory of attributes: consistency and independence of data with special reference to attributes.

UNIT II

Measures of Central Tendency: Mathematical and positional, partition values, Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, skewness and kurtosis, Sheppard's corrections.

UNIT III

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability-classical, statistical, and axiomatic.Conditional Probability, Addition and multiplication theorem of probability, independent events, Theorem of Total probability, Bayes' theorem and its applications.

UNIT IV

Random variables: discrete and continuous, illustrations and properties of random variables, pmf, pdf and cdf, Two dimensional random variables: Joint, marginal and conditional pmf/pdf, independence of random variables. Univariate transformation. Mathematical Expectation: Expectation of random variables and its properties.

SUGGESTED READINGS:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002). *Fundamentals of Statistics*, Vol. I, 8th Ed. The World Press, Kolkata.
2. Miller, I. and Miller, M. (2006). *John E. Freund's Mathematical Statistics with Applications*, 7th Ed., Pearson Education, Asia.
3. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007). *Introduction to the Theory of Statistics*, 3rd Ed., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
4. Ross, S.M. (2002). *A first course in Probability,* 6th Ed., Pearson.
5. Ross, S. M. (2010). *Introductory statistics,* 3rd Ed., Academic Press.

PRACTICAL/LAB WORK
List of Practicals

1. Presentation of data in:
    a) Discrete & Continuous frequency table
    b) Cumulative frequency table
2. Graphical representation of data-
    a) Frequency curve, frequency polygon and histogram
    b) Ogives
3. Measures of Central tendency:
    a) Based on Arithmetic mean:
    - Formulae (Direct Method)
    - Change of Origin and Scale

    b) Based on Median and partition values:
    - Formulae (Direct Method)
    - Graphically

    c) Based on Mode:

- Formulae (Direct Method)
- Graphically
- By the method of grouping

4. Measures of Dispersion -
   a) Quartile deviation using formula and graphically
   b) Mean Deviation
   c) Standard deviation and variance:
   - Formulae (direct method)
   - Change of origin & Scale
5. Coefficient of dispersion and variation
6. Combined mean and combined variance
7. Raw moments
8. Moments about any arbitrary point
9. Central Moments
10. Moments using relation between Raw moments, Moments about any arbitrary point and Central Moments
11. Correct moments involving wrong data
12. Skewness based on mean, median, mode and standard deviation
13. Skewness and kurtosis based on moments
14. Problem based on missing frequencies
15. Theory of attributes-
    a) Representation of word problems in the form of class frequencies
    b) Based on Fundamental set of class frequencies
    c) Association and independence of attributes.

Week –wise Teaching Plan

Week 1	Definition and scope of Statistics, concepts of statistical population and sample.Data: quantitative and qualitative, attributes, variables, scales of measurement-nominal, ordinal, interval and ratio.
Week 2	Tabular and graphical presentation, including histogram and Ogives.
Week 3	Theory of attributes, consistency and independence of data with special reference to attributes.
Week 4	Mathematical and positional measures of Central Tendency, Partition values.
Week 5	Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation.
Week 6	Moments, absolute moments, factorial moments, skewness and kurtosis, Sheppard's corrections.
Week 7	Probability introduction, random experiments, sample space, events and algebra of events.

Week 8	Classical, statistical, and axiomatic definitions of Probability, Conditional Probability.
Week 9	Addition and multiplication theorem of probability, independent events, Theorem of Total probability.
Week 10	Bayes' theorem and its applications.
Week 11	Discrete and continuous random variables, illustrations and properties of random variables.
Week 12	pmf, pdf and cdf.
Week 13	Two dimensional random variables: Joint, marginal and conditional pmf/pdf.
Week 14	Independence of random variables. Univariate transformations.
Week 15	Expectation of random variables and its properties.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Concepts of statistical population and sample, variables and attributes.	Classroom lectures and discussions.	Participation in class discussions.
I	Tabular and graphical representation of data based on variables.	(i) Classroom lectures and discussions. (ii) Practical work.	Participation in class discussions. Ability to apply concepts in practical examples.
I	'Conditions for the consistency' and criteria for the independence of data based on attributes.	(i)Classroom lectures and discussions. (ii) Practical work.	Participation in class discussions. Ability to apply concepts in practical examples.
II	Measures of central tendency, Dispersion, Skewness and Kurtosis.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussions. Ability to apply concepts in practical examples.
II	Moments and their use in studying various characteristics of data.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussions. Ability to apply concepts in practical examples.
			Class test/assignment on first two units
III	Different approaches to the theory of probability.	Classroom lectures and discussions.	Participation in class discussions.
III	Important theorems on probability and their use in solving problems.	Classroom lectures and discussions	Participation in class discussions.

IV	Concept of random variables and its probability distributions.	Classroom lectures and discussions.	Participation in class discussions.
IV	Concept of joint, marginal and conditional probability distribution for two dimensional random variables and their independence.	Classroom lectures and discussions.	Participation in class discussions.
IV	Univariate transformation and expectation of random variables.	Classroom lectures and discussions.	Participation in class discussions.
			Class test/assignment on last two units.

Keywords: Mathematical and positional measures of Central Tendency, Measures of Dispersion, Probability introduction, Theory of attributes, Bayes' theorem Discrete and continuous random variables.

Bachelor of Science (Hons.) in Statistics

Semester I

STAT-C-102: CALCULUS

Credits: 6 **Marks: 100**

Course Objectives:

The learning objectives include:

- Fundamentals of differential calculus/Integral calculus/Differential Equation/Partial differential equation.
- To analyse the problem and its solution.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of Differential calculus.
- Solving complicated integrals.
- Finding complete Solution of differential equations.
- Searching solution of partial differential equation.

UNIT I

Differential Calculus**:** Limits of function, continuous functions, properties of continuous functions, partial differentiation and total differentiation. Indeterminate forms: L-Hospital's rule, Leibnitz rule for successive differentiation. Euler's theorem on homogeneous functions. Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems. Jacobian, concavity and convexity, points of inflexion of function, singular points. Theory of asymptotes (Only for cartisian forms).

UNIT II

Integral Calculus**:** Review of integration and definite integral. Differentiation under integral sign, double integral, change of order of integration, transformation of variables. Beta and Gamma functions: properties and relationship between them.

UNIT III

Differential Equations**:** Exact differential equations, Integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Differential equations of first order but not of first degree, Equations solvable for x, y, q, Equations of the first degree in x and y, Clairaut's equations. Higher Order Differential Equations**:** Linear differential equations of order n, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals, Linear differential equations with non-constant coefficients, Reduction of order method, The Cauchy-Euler's equation of order n, Legendre's linear equation.

UNIT IV

Formation and solution of a partial differential equations**.** Equations easily integrable. Linear partial differential equations of first order. Non-linear partial differential equation of first order and their different forms. Charpit's method. Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals.

SUGGESTED READINGS:

1. Prasad, G. (1997). *Differential Calculus*, 14th Ed., Pothishala Pvt. Ltd., Allahabad.
2. Prasad, G. (2000). *Integral Calculus*, 14th Ed., Pothishala Pvt. Ltd., Allahabad.
3. Ahsan, Z. (2004). *Differential Equations and their Applications*, 2nd Ed., Prentice-Hall of India Pvt. Ltd., New Delhi.

PRACTICAL/LAB WORK: NO PRACTICALS

Week-wise Teaching Plan:

Week 1	Limits of function, continuous functions. Properties of continuous functions.
Week 2-3	Partial differentiation and total differentiation. Indeterminate forms: L-Hospital's rule.
Week 4	Leibnitz rule for successive differentiation. Euler's theorem on homogeneous functions.
Week 5	Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems.
Week 6	Jacobian, concavity and convexity, points of inflexion of function, singular points. Theory of Asymptotes (Only for Cartesian forms).
Week 7	Integral Calculus: Review of integration and definite integral. Differentiation under integral sign.
Week 8	Double integral, change of order of integration, transformation of variables.
Week 9	Beta and Gamma functions: properties and relationship between them.
Week 10	Differential Equations: Exact differential equations, Integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Differential equations of first order but not of first degree, Equations solvable for x, y, q, Equations of the first degree in x and y, Clairaut's equations.
Week 11	Higher Order Differential Equations: Linear differential equations of order n, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals.
Week 12	Linear differential equations with non-constant coefficients, Reduction of order method. The Cauchy-Euler's equation of order n, Legendre's linear equation.
Week 13	Formation and solution of a partial differential equations**.** Equations easily integrable. Linear partial differential equations of first order. Non-linear partial differential equation of first order and their different forms. Charpit's method.
Week 14-15	Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Limits of function, continuous functions. Properties of continuous functions.	Class room lectures and discussions.	Participation in class discussion and problem solving.
I	Partial differentiation and total differentiation. Indeterminate forms: L-Hospital's rule.		
I	Leibnitz rule for successive differentiation. Euler's theorem on homogeneous functions.		
I	Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems.		
I	Jacobian, concavity and convexity, points of inflexion of function, singular points. Theory of Asymptotes (Only for Cartesian forms).		
II	Integral Calculus: Review of integration and definite integral. Differentiation under integral sign.	Class room lectures and discussions.	Participation in class discussion and problem solving.
II	Double integral, change of order of integration, transformation of variables.		
II	Beta and Gamma functions: properties and relationship between them.		
III	Differential Equations: Exact differential equations, Integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Differential equations of first order but not of first degree, Equations solvable for x, y, q, Equations of the first degree in x and y, Clairaut's equations.	Class room lectures and discussions.	Participation in class discussion and problem solving.
III	Higher Order Differential Equations: Linear differential equations of order n, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals.		
III	Linear differential equations with non-constant coefficients, Reduction of order method. The Cauchy-Euler's equation of order n, Legendre's linear equation.		
IV	Formation and solution of a partial differential equations. Equations easily integrable. Linear partial differential equations of first order. Non-linear partial differential equation of first	Class room lectures and discussions.	Participation in class discussion

	order and their different forms. Charpit's method		and problem solving.
IV	Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals.		

Keywords: Limits of function, L-Hospital's rule, Jacobian, concavity and convexity, Differentiation under integral sign, Exact differential equations, Higher Order Differential Equations, Formation and solution of a partial differential equations, Homogeneous linear partial differential equations with constant coefficients.

Bachelor of Science (Hons.) in Statistics
Semester II
STAT-C-201: Probability and Probability Distributions

Credits: 6 **Marks:150**

Course Objective:
The purpose is to familiarize the students about the basic concepts required for further studies of advanced curriculum.

Course Learning Outcomes:
After completing this course, there should be a clear understanding of:
- The fundamental concept of expectation for univariate and bivariate random variables with their distributions and properties.
- Moment generating function, cumulant generating function and characteristic function.
- Discrete probability distributions with their properties.
- Continuous probability distributions with their properties.

Contents:

UNIT I

Mathematical Expectation: Variance and covariance of random variables and their properties, conditional expectations. Bivariate transformations with illustrations. Moments, moment generating function and its properties. Cumulants, cumulant generating function and its properties. Characteristic function and its properties. Inversion theorem for continuous random variables (without proof) along with applications.

UNIT II

Bivariate data: Definition, scatter diagram, Karl Pearson's coefficient of correlation. Spearman's rank correlation coefficient. Principle of least squares and fitting of polynomials and exponential curves. Linear regression. Partial and multiple correlation (3 variables only).

UNIT III

Discrete Probability Distributions: Uniform, Binomial, Poisson, Geometric, Negative Binomial and Hyper-geometric distributions along with their characteristic properties and limiting/approximation cases.

UNIT IV

Continuous probability distributions: Normal, Exponential, Uniform, Beta, Gamma, Cauchy, lognormal and Laplace distributions along with their characteristic properties and limiting/approximation cases.

SUGGESTED READINGS:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002). *Fundamentals of Statistics*, Vol. I, 8th Ed., The World Press, Kolkata.
2. Hogg, R.V., Tanis, E.A. and Rao, J.M. (2009). *Probability and Statistical Inference*, 7th Ed., Pearson Education, New Delhi.
3. Miller, I. and Miller, M. (2006). *John E. Freund's Mathematical Statistics with Applications*, 8th Ed., Pearson Education, Asia.
4. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007). *Introduction to the Theory of Statistics*, 3rd Ed., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

PRACTICAL/LAB WORK
List of Practicals

1. Fitting of polynomials, exponential curves.
2. Karl Pearson correlation coefficient.
3. Correlation coefficient for a bivariate frequency distribution.
4. Lines of regression, angle between lines and estimated values of variables.
5. Spearman rank correlation with and without ties.
6. Partial and multiple correlations.
7. Planes of regression and variances of residuals for given simple correlations.
8. Fitting of binomial distributions.
9. Fitting of Poisson distributions.
10. Fitting of negative binomial distribution.
11. Fitting of suitable distribution.
12. Application problems based on binomial distribution.
13. Application problems based on Poisson distribution.
14. Application problems based on negative binomial distribution.
15. Problems based on area property of normal distribution.
16. To find the ordinate for a given area for normal distribution.
17. Application based problems using normal distribution.
18. Fitting of normal distribution.

Week-wise Teaching plan

Mathematical Expectation	
Week 1	Variance and covariance of random variables and their properties, Conditional expectations.
Week 2	Bivariate transformations with illustrations.
Weeks 3-4	Moments, moment generating function and its properties. Cumulants, cumulant generating function and its properties. Characteristic function and its properties. Inversion theorem for continuous random variables (without proof) along with applications.
Bivariate Data	
Week 5	Definition, scatter diagram, Karl Pearson's coefficient of correlation. Spearman's rank correlation coefficient. Practical work
Week 6	Principle of least squares and fitting of polynomials and exponential curves.

	Practical work
Week 7	Linear regression. Partial and multiple correlation (3 variables only). Practical work
Discrete Probability distributions along with their characteristic properties and limiting/approximation cases.	
Week 8-9	Binomial and Poisson distributions. Practical work
Week 9-10	Uniform, Geometric, Negative Binomial distributions.
Week 11	Hypergeometric distributions.
Continuous probability distributions along with their characteristic properties and limiting/approximation cases.	
Week 12-13	Uniform, Normal and lognormal distribution. Practical work
Week 14-15	Exponential, Beta, Gamma, Cauchy & Laplace Distribution.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Introduction of variance, covariance, conditional expectation with their related properties.	Class room lectures and discussions.	Participation in class discussion.
I	Concept bivariate transformations with illustrations for discrete as well as continuous random variables.	Class room lectures and discussions.	Participation in class discussion.
I	Moments, moment generating function, cumulants, cumulant generating function and characteristic function and their relationship with properties.	Class room lectures and discussions.	Participation in class discussion and quiz (optional).
A*	Understanding of above basic concepts used in statistics.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.
II	Understanding of bivariate data through scatter diagram and correlation coefficients (Karl pearson& Spearman's rank).	(i)Class room lectures and discussions. (ii) Practical work.	Participation in class discussion with identification of different types of correlation coefficients.
II	Fitting of polynomials and curves using method of least squares.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion and surprise test (optional).
II	Linear regression, multiple	(i) Class room	Participation in class

	and partial correlation.	lectures and discussions. (ii) Practical work.	discussions.
III	Discrete probability distributions: Bernoulli, Binomial, Poisson, Geometric, Negative Binomial, Uniform and hypergeometric distributions.	(i) Class room lectures and discussions. (ii)Practical work.	Participation in class discussion. How Binomial is obtained from Bernoulli distribution and the limiting cases of all the distributions.
IV	Continous probability distributions: Uniform Normal, log normal, exponential Gamma, Beta, Cauchy and Laplace.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion and limiting distribution towards normal distribution.
B*	Understanding of different types of correlations and regressions.	Class Test/ Assignment work.	
C*	Understanding of applications for Binomial, Poisson, Negative Binomial and normal distribution.	Class Test/ Assignment work for practical.	
D*	Understanding of discrete and continuous distributions.	Class Test/ Assignment work.	Ability to apply different distributions.

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Variance and covariance of random variables and their properties, Conditional expectations, Bivariate transformations with illustrations, Moments generating function, Bivariate Data, Karl Pearson's coefficient of correlation, fitting of polynomials and exponential curves, Discrete and Continuous Probability distributions along with their characteristic properties and limiting/approximation cases.

Bachelor of Science (Hons.) in Statistics

Semester II

STAT C-202: Algebra

Credits: 6 **Marks: 150**

Course Objectives:

Algebra serves as a building block that will enable students to learn more advanced techniques that will help them to solve problems more quickly and easily.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Theory of Equations
- The fundamental concepts of matrices and determinants
- Echelon form
- Linear equations
- Rank of a Matrix
- Characteristic roots and vectors
- Quadratic forms
- Partitioning of matrices
- Generalized inverse

Contents:

UNIT I

Theory of equations, statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients or any polynomial equations. Solutions of cubic and biquadratic equations when some conditions on roots of equations are given. Evaluation of the symmetric polynomials and roots of cubic and biquadratic equations. Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem.

UNIT II

Algebra of matrices - A review, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices, singular and non-singular matrices and their properties. Trace of a matrix, unitary, involutory and nilpotent matrices. Adjoint and inverse of a matrix and related properties.

UNIT III

Determinants of Matrices: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, Circulant determinants, Jacobi's Theorem, product of determinants. Use of determinants in solution to the system of linear equations, row reduction and echelon forms, the matrix equations AX=B, solution sets of linear equations, linear independence, Applications of linear equations, inverse of a matrix.

UNIT IV

Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Generalized inverse (concept with illustrations). Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms, Linear orthogonal transformation and their digitalization.

SUGGESTED READINGS:

1. Artin M. (1994). *Algebra*. Prentice Hall of India.
2. Biswas, S. (1997). *A Textbook of Matrix Algebra*, New Age International.
3. Gupta, S.C. (2008). *An Introduction to Matrices (Reprint).* Sultan Chand & Sons.
4. Hadley, G. (2002). *Linear Algrbra*. Narosa Publishing House (Reprint).
5. Jain, P.K. and Ahmad, K. (1973). *Metric Spaces*, Narosa Publishing House, New Delhi.
6. Krishnamurthy, V., Mainra, V.P. and Arora, J.L. (2015). *An Introduction to Linear Algebra*, East West Press Pvt. Ltd., New Delhi.
7. Lay, D. C. (2000). *Linear Algebra and its Applications*, Addison Wesley.
8. Searle, S.R. (1982). *Matrix Algebra Useful for Statistics*. John Wiley &Sons.

PRACTICAL/LABWORK
List of Practicals:

1. Finding inverse using Cayley Hamilton theorem.
2. For a real Skew Symmetric matrix S, show that matrix A defined by (I-S) (I+S)-1 is an orthogonal matrix.
3. Reducing a Quadratic Form to its canonical form and finding its rank and index.
4. Proving that a quadratic form is positive or negative definite.
5. Finding the product of two matrices by considering partitioned matrices.
6. Finding inverse of a matrix by partitioning.
7. Finding Generalized Inverse of a matrix and symmetric generalized inverse of a matrix
8. To show that matrix A defined as A= $(I_n - X(X'X)^{-1}X')$ is idempotent. Also, determine its rank and characteristic root. Repeat the process by finding a generalized inverse of X'X if inverse does not exist.
9. Find XGX' for any X of order nxk, where G is generalized inverse and show that XGX' is invariant with respect to G.
10. To find whether a given set of vectors is linearly dependent or linearly independent.
11. Constructing an Orthonormal Basis using Gram Schmidt Orthogonalization Process.

Week –wise Teaching Plan:

Week 1	Statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients or any polynomial equations.
Week 2	Solutions of cubic and biquadratic equations when some conditions on roots of equations are given. Evaluation of the symmetric polynomials and

	roots of cubic and biquadratic equations.
Week 3-4	Review of algebra of matrices, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices, singular and non-singular matrices and their properties. Trace of a matrix, unitary, involutory and nilpotent matrices. Practical work.
Week 5	Adjoint and inverse of a matrix and related properties. Practical work.
Week 6-7	Definition, properties and applications of determinants for 3^{rd} and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, Circulant determinants, Jacobi's Theorem, product of determinants. Use of determinants in solution to the system of linear equations.
Week 8-9	Row reduction and echelon forms, the solution of matrix equations AX=B, linear independence, Applications of linear equations, inverse of a matrix. Practical work.
Week 10	Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Practical work.
Week 11	Generalized inverse (concept with illustrations). Practical work.
Week 12	Partitioning of matrices and simple properties. Practical work.
Week 13-14	Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem. Practical work.
Week 15	Quadratic forms, Linear orthogonal transformation and their digitalization. Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Theory of Equations.	Class room lectures.	Solving problems.
II, III	The fundamental concepts of matrices and determinants.	Class room lectures with practical work.	Solving problems.
III	Echelon form, Linear equations.	Class room lectures with practical work.	Solving problems.
IV	Rank of a Matrix, Characteristic roots and vectors, Quadratic forms.	Class room lectures with practical work.	Class test*.
IV	Partitioning of matrices.	Class room lectures with practical work.	Assignment* work on different kinds of partitioned matrices.
IV	Generalized inverse.	Class room lectures with practical work.	Identification of cases for application.

*As per the requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Theory of Equations, The fundamental concepts of matrices and determinants, Echelon form, Linear equations, Rank of a Matrix, Characteristic roots and vectors, Quadratic forms Partitioning of matrices, Generalized inverse.

Bachelor of Science (Hons.) in Statistics
Semester III
STAT-C-301: Sampling Distributions

Credits: 6 **Marks: 150**

Course Objectives:

The learning objectives include:

- To understand the concept of sampling distributions and their applications in statistical inference.
- To understand the process of hypothesis testing.
- To have a clear understanding of when to apply various tests of hypothesis about population parameters using sample statistics and draw appropriate conclusions from the analysis.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Laws of convergence, their inter relations and applications.
- Central Limit Theorem and its applications.
- Order statistics and distribution of sample median and range.
- Basic concepts of hypothesis testing, including framing of null and alternative hypothesis.
- Hypothesis testing based on a single sample and two samples using both classical and p value approach.
- Chi square distribution.
- Analyze categorical data by using Chi square techniques.
- t and F distributions and their applications.

Contents:

UNIT I

Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their inter relations, Chebyshev's inequality, W.L.L.N., S.L.L.N. and their applications, De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T. and Liapunov Theorem (without proof). Order Statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and sth order statistics, distribution of sample median and sample range.

UNIT II

Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches.

UNIT III

Exact sampling distribution: Definition and derivation of pdf of $\chi 2$ with n degrees of freedom (d.f.) using mgf, nature of pdf curve for different degrees of freedom, mean, variance, mgf, cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution. Tests of significance and confidence intervals based on χ^2 distribution.

UNIT IV

Exact sampling distributions: Student's and Fishers t-distribution, Derivation of its pdf, nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. Derivation of distribution of sample correlation coefficient when population correlation coefficient is zero (Sawkin's Methods).Snedecore's F-distribution: Derivation of pdf, nature of pdf nature of pdf curve with different degrees of freedom, mean, variance and mode. Distribution of 1/F(n1,n2). Relationship between t, F and $\chi 2$ distributions. Test of significance and confidence Intervals based on t and F distributions.

SUGGESTED READINGS:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003). *An Outline of Statistical Theory*, Vol. I, 4th Ed., World Press, Kolkata.
2. Hogg, R.V. and Tanis, E.A. (2009). *A Brief Course in Mathematical Statistics*. Pearson Education.
3. Johnson, R.A. and Bhattacharya, G.K. (2001). *Statistics-Principles and Methods*, 4th Ed., John Wiley and Sons.
4. Mood, M.A., Graybill, F.A. and Boes, C.D. (2007). *Introduction to the Theory of Statistics*, 3rd Ed., (Reprint).Tata McGraw-Hill Pub. Co. Ltd.
5. Rohatgi, V. K. and Saleh, A.K. Md. E. (2009). *An Introduction to Probability and Statistics*, 2nd Ed., (Reprint) John Wiley and Sons.

PRACTICAL/LAB WORK
List of Practicals

1. Large Sample Tests:

   a) Testing of significance and confidence intervals for single proportion and difference of two proportions.
   b) Testing of significance and confidence intervals for single mean and difference of two means.
   c) Testing of significance and confidence intervals for difference of two standard deviations.

2. Tests based on Chi-Square Distribution:
   a) To test if the population variance has a specific value and its confidence intervals.
   b) To test the goodness of fit.
   c) To test the independence of attributes.
   d) Test based on 2 X 2 contingency table without and with Yates' corrections.
   e) To test the homogeneity of independent estimates of population correlation coefficient.
3. Tests based on t- Distribution and F- Distribution:
   a) Testing of significance and confidence intervals for single mean and difference of two means and paired t – test.
   b) Testing of significance and confidence intervals of an observed sample correlation coefficient.
   c) Testing and confidence intervals of equality of two population variances.
   d) Testing of significance of an observed multiple correlation coefficients.

Week –wise Teaching Plan

Week 1-2	Limit laws, different types of convergence and their inter relations, Central Limit Theorem (CLT), applications and examples based on CLT.
Week 3–4	Order statistics: distribution of r^{th} order, largest and smallest order statistics and joint distribution of two order statistics, distribution of sample median and range. Examples based on theory.
Week 5	Sampling distributions: definition of parameter, statistic, standard error and their concepts, Sampling distribution of various statistics.
Week 6	Introduction to hypothesis testing (classical and p value approach): formulation of null and alternative hypothesis, Type I and Type II errors, level of significance and critical region. Examples based on these.
Week 7-8	Large sample tests: for single mean, single proportion, difference of two means, difference of two proportions, difference of two standard deviations all with examples. Examples and practical work based on these tests.
Week 9-11	Chi square distribution: Definition and derivation of pdf of $\chi 2$ with n degrees of freedom (d.f.) using mgf, nature of pdf curve for different degrees of freedom, mean, variance, mgf, cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution. Tests of significance and confidence intervals based on Chi-Square Distribution. Includes examples and practical work.
Week12-13	Student's and Fishers t-distribution: Derivation of pdf, nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of the distribution, Distribution of sample correlation coefficient when population correlation coefficient is zero. Tests of significance and confidence intervals based on t distribution. Includes examples and practical work.
Week14-15	Distribution of F statistic: derivation of pdf, nature of probability curve with different degrees of freedom, mean, variance, moments, mode and limiting form of the distribution, points of inflexion. Distribution of 1/F(n1,n2). Relationship between t, F and $\chi 2$ distributions. Test of significance and confidence intervals based on F distribution. Includes examples and practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	The laws of convergence, Central Limit Theorem and its applications.	Class room lectures and discussions.	Participation in class discussion.
I	Order statistics and distribution of sample median and range.	Class room lectures and discussions.	Participation in class discussion.
II	Introduction to sampling distributions.	Class room lectures and discussions.	Participation in class discussion.
II	Basic concepts of hypothesis testing.	Class room lectures and discussions.	Participation in class discussion.
II	Large sample tests using classical and p value approach.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion. Ability to apply concepts in practical examples.
			Class test/assignment on first two units.
III	Chi square distribution: definition, derivation of its pdf and properties.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion. Ability to apply concepts in practical examples.
III	Tests of significance and confidence intervals based on χ^2 distribution.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion. Ability to apply concepts in practical examples.
IV	Student's t distribution and its applications.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion. Ability to apply concepts in practical examples.
IV	F distribution and its applications.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion. Ability to apply concepts in practical examples.
			Class test/assignment on last two units.

Keywords: Law of large numbers, Sampling distribution, Tests of significance, Hypotheses, Critical region, p-value, Order statistics.

Bachelor of Science (Hons.) in Statistics
Semester III
STAT-C-302: Survey Sampling and Indian Official Statistics

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include:

- To provide tools and techniques for selecting a sample of elements from a target population keeping in mind the objectives to be fulfilled and nature of population.
- To obtain estimator of the population parameter on the basis of selected sample and study its properties.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of population and sample. (or The basic concepts of survey)
- The principles of sample survey and the steps involved in selecting a sample.
- Simple Random Sampling.
- Stratified Sampling.
- Systematic Sampling.
- Ratio and Regression Methods of Estimation.
- Cluster Sampling (equal size clusters).
- Sub Sampling.
- Indian Official Statistics.

Contents:

UNIT I

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.

UNIT II

Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision, post stratification and its performance, Collapsed Strata. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates ($N = n\times k$). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections. Circular systematic sampling (only definition).

UNIT III

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS. Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation. Concept of sub sampling.

UNIT IV

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.

SUGGESTED READINGS:

1. Cochran, W.G. (2011). *Sampling Techniques*, 3rd Ed., Wiley Eastern John Wiley and Sons.
2. Raj, D. and Chandhok, P. (1998). *Sample Survey Theory*, Narosa Publishing House.
3. Goon, A. M., Gupta, M. K. and Dasgupta, B. (2001). *Fundamentals of Statistics*, Vol.2, World Press.
4. *Guide to current Indian Official Statistics, Central Statistical Office*, GOI, New Delhi.
5. Gupta, S.C. and Kapoor, V.K. (2014). *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand.
6. mospi.nic.in/nscr/iss.html.
7. Murthy M.N. (1977). *Sampling Theory & Statistical Methods*, Statistical Pub. Society, Calcutta.
8. Sukhatme, P. V., Sukhatme, B. V., Sukhatme, S., Asok, C.(1984). *Sampling Theories of Survey with Application*, IOWA State University Press and Indian Society of Agricultural Statistics.
9. Singh, D. and Chaudhary, F. S. (2015). *Theory and Analysis of Sample Survey Designs.*
10. www.emathzone.com/tutorials/basics-statistics/collection-of-stastical-data.htm.l
11. https://cyfars.org/data-collection-technique.

PRACTICAL/LAB WORK
List of Practicals:

1. To select SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and

population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.

3. For SRSWOR, estimate mean, standard error, the sample size.
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Compare the efficiencies of above two methods relative to SRS.
5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend and using end's correction.
7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.
8. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra-class correlation coefficient, efficiency as compared to SRS.

Week-wise Teaching Plan

Week 1-2	Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey.
Week 3-4	Simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination. Practical work.
Week 5-7	Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision, post stratification and its performance, Collapsed strata. Practical work.
Week 8	Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates ($N = n \times k$). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections. Circular systematic sampling (only definition). Practical work.
Week 9-10	Introduction to ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS. Practical work.
Week 11-12	Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation. Concept of sub sampling. Practical work.
Week 13-15	Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Basic concepts of survey.	Class room lectures and discussions.	Participation in class discussion.
I	Principles of sample survey and steps involved in selecting a sample.	Class room lectures and discussions.	Participation in class discussion.
I	Simple Random Sampling.	(i) Class room lectures and discussions. (ii) Practical work based on the design and analysis.	(i) Participation in class discussion. (ii)Applying appropriate sampling technique to draw sample and obtaining estimates of the population parameters. Interpretation and comparison of results and conclusions.
II	Stratified Sampling.		
A*	Understanding of basic concepts and techniques.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.
II	Systematic Sampling.	(i) Class room lectures and discussions. (ii) Practical work based on the design and analysis.	(i) Participation in class discussion. (ii)Applying appropriate sampling technique to draw sample and obtaining estimates of the population parameters. Interpretation and comparison of results and conclusions.
III	Ratio and Regression methods of estimation.		
III	Cluster Sampling and Sub sampling.		
IV	Indian Official Statistics.	Class room lectures and discussions.	Participation in class discussion and presentation.
B*	Understanding of various techniques of sampling and Indian official statistics.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.
C	Application of Survey Sampling. (optional)	Project work and its presentation.	Ability to apply concepts of sampling and obtain the required estimates of the population parameters.

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Population and sample, Simple Random Sampling, Stratified Sampling, Ratio and regression methods of estimation, Cluster Sampling, Indian Official Statistics

Bachelor of Science (Hons.) in Statistics
Semester III
STAT-C-303: Mathematical Analysis

Credits: 6 **Marks:150**

Course Objectives:
The learning objectives include:
- To study the Real Analysis, this deals with the analytical properties of real functions and sequences.
- To study the Numerical Analysis, this is the study of algorithms that use numerical approximation for the problems of mathematical analysis.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- Fundamental properties of real number and real-valued functions.
- Analytical properties of sequences.
- Infinite series, their properties and different tests.
- Limits, continuity, differentiability and mean value theorems.
- Fundamentals of numerical analysis, interpolation, numerical integration and difference equation.

UNIT I

Real Analysis: Representation of real numbers as points on the line and the set of real numbers as complete ordered field. Bounded and unbounded sets, neighborhoods and limit points, Supremum and infimum, derived sets, open and closed sets, sequences and their convergence, limits of some special sequences such as $r^n, \left(1+\frac{1}{n}\right)^n$ *and* $n^{\frac{1}{n}}$ and Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence.

UNIT II

Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's n^{th} root test, Raabe's test. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only). Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence.

UNIT III

Review of limit, continuity and differentiability, uniform Continuity and boundedness of a function. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with Lagrange's and Cauchy's form of remainder (without proof). Taylor's and Maclaurin's series expansions of sinx, cosx, $e^x, (1+x)^n$, log (1+x).

UNIT IV

Numerical Analysis: Factorial, finite differences and interpolation. Operators, E and divided difference. Newton's forward, backward and divided differences interpolation formulae.

Lagrange's interpolation formulae. Central differences, Gauss and Stirling interpolation formulae. Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eights rule, Weddle's rule with error terms. Stirling's approximation to factorial n. Solution of difference equations of first order.

SUGGESTED READINGS:

1. Appostol, T.M. (1987). *Mathematical Analysis*, 2nd Ed., Narosa Publishing House, New Delhi.
2. Bartle, R.G. and Sherbert, D.R. (2002). *Introduction to Real Analysis*, (3rd Ed.,), John Wiley and Sons (Asia) Pte. Ltd., Singapore.
3. Ghorpade, S.R. and Limaye, B.V. (2006). *A Course in Calculus and Real Analysis,* Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
4. Jain, M.K., Iyengar, S.R.K. and Jain, R.K. (2003). *Numerical methods for scientific and engineering computation,* New age International Publisher, India.
5. Malik, S.C. and Arora, S. (1994). *Mathematical Analysis,* Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.
6. Mukherjee, Kr. Kalyan (1990). *Numerical Analysis.* New Central Book Agency.
7. Sastry, S.S. (2000). *Introductory Methods of Numerical Analysis,* 3rd Ed., Prentice Hall of India Pvt. Ltd., New Delhi.
8. Narayan, S. (1987). *A course of Mathematical Analysis*, 12^{th} revised Ed., S. Chand & Co. (Pvt.) Ltd., New Delhi.
9. Somasundram, D. and Chaudhary, B. (1987). *A First Course in Mathematical Analysis*, Narosa Publishing House, New Delhi.

PRACTICAL/LAB WORK
List of Practicals:

1. Formation of difference table, fitting of polynomial and missing terms for equal interval of differencing.
2. Based on Newton's Gregory forward difference interpolation formula.
3. Based on Newton's backward difference interpolation formula.
4. Based on Newton's divided difference and Lagrange's interpolation formula.
5. Based on Gauss forward, Gauss backward central difference interpolation formula.
6. Based on Stirling's central difference interpolation formula.
7. Based on Lagrange's Inverse interpolation formula.
8. Based on method of successive approximation or iteration.
9. Based on method of reversion of series.
10. Based on Trapezoidal Rule, Simpson's one-third rule, Simpson's three-eighth rule, Weddle's rule.
11. To find sum by Euler-Maclaurin summation formula.

Week-wise Teaching Plan

Week 1	Real Analysis: Representation of real numbers as points on the line and the set of real numbers as complete ordered field. Bounded and unbounded sets, neighbourhoods and limit points, Supremum and infimum, derived sets, open and closed sets.
Week 2-3	Sequences and their convergence, limits of some special sequences such as $r^n, \left(1+\frac{1}{n}\right)^n$ and $n^{\frac{1}{n}}$ and Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence.
Week 4-5	Series: Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's n^{th} root test, Raabe's test. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only).
Week 6	Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence.
Week 7	Review of limit, continuity and differentiability, uniform Continuity and boundedness of a function.
Week 8-9	Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with Lagrange's and Cauchy's form of remainder (without proof). Taylor's and Maclaurin's series expansions of sinx, cosx, $e^x, (1+x)^n$, log (1+x).
Week 10-11	Numerical Analysis: Factorial, finite differences and interpolation. Operators, E and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Practical work
Week 12	Central differences, Gauss and Stirling interpolation formulae. Practical work
Week 13-14	Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eight rule, Weddle's rule with error terms. Stirling's approximation to factorial n. Practical work
Week 15	Solution of difference equations of first order. Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Fundamental properties of real numbers and real-valued functions.	Class room lectures and discussions.	Participation in class and discussion.
I	Analytical properties of sequences.	Class room lectures and discussions.	Participation in class and discussion.
A*	Understanding of fundamentals and related properties of real numbers, real-valued functions and sequences.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts
II	About infinite series their properties and tests.	(i) Class room lectures and	Participation in class and

III	About limits, continuity, differentiability and Mean Value Theorems and their uses.	discussions. (ii) Practical work based on the numerical analysis.	discussion.
IV	Fundamentals of numerical analysis including interpolation, numerical integration and difference equation.		
B*	Understanding of infinite series, limits, continuity, finite differences, interpolation, numerical integration and difference equation.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.

* As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Real Analysis, Sequences and their convergence, Numerical Analysis, Central differences, Numerical integration, Solution of difference equations of first order.

Bachelor of Science (Hons.) in Statistics
Semester IV
STAT-C-401: Statistical Inference

Credit 6 **Marks:150**

Course Objectives:
The learning objectives include:
- Drawing inference about the unknown population parameters based on random samples.
- Validating our estimation/ inference about the population using hypothesis testing.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
1. Different methods of finding point estimators for unknown population parameters, their advantages and disadvantages:
   - Maximum Likelihood Estimation
   - Method of Moments
   - Method of Minimum Chi square and Modified Minimum Chi square
2. Desirable properties of point estimators based on which estimators can be compared:
   - Unbiasedness
   - Consistency
   - Efficiency
   - Sufficiency
3. Methods to develop/find best point estimators based on the desirable properties (Using Cramer- Rao inequality, Rao-Blackwell theorem, and Lehmann-Scheffe Theorem).
4. General methods of constructing interval estimators (Confidence Intervals) for unknown population parameters.
5. Basic principle of Bayesian estimation (Finding posterior distributions of unknown population parameters).
6. Developing/ constructing best/most powerful statistical tests to test hypotheses regarding unknown population parameters (Using Neyman-Pearson Lemma and Likelihood Ratio tests).
7. Practical applications of estimation theory and hypothesis testing pertaining to all discussed methods.

Contents:

UNIT I

Estimation: Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency. Fisher- Neyman Criterion (statement and applications), Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality, MVB estimators and their applications.

UNIT II

Methods of Estimation: Method of moments, method of maximum likelihood estimation, method of minimum Chi-square, basic idea of Bayes estimators.

UNIT III

Principles of test of significance: Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, level of significance, size and power, best critical region, most powerful test, uniformly most powerful test, uniformly most powerful unbiased critical region (UMPU). Neyman Pearson Lemma and its applications to construct most powerful test. Likelihood ratio test, properties of likelihood ratio tests (without proof).

UNIT IV

Interval estimation: Confidence interval for the parameters of various distributions, Confidence interval for Binomial proportion, Confidence interval for population correlation coefficient for Bivariate Normal distribution, Pivotal quantity method of constructing confidence interval, Large sample confidence intervals.

SUGGESTED READINGS:

1. Bhat, B.R, Srivenkatramana, T. and Rao, Madhava K.S. (1997). *Statistics: A Beginner's Text*, Vol. I, New Age International (P) Ltd.
2. Dudewicz, E. J., and Mishra, S. N. (1988). *Modern Mathematical Statistics*. John Wiley & Sons.
3. Goon, A.M., Gupta, M.K.,and Dasgupta, B. (2005). *Fundamentals of Statistics*, Vol. I, World Press, Kolkata.
4. Miller, I. and Miller, M. (2002). *John E. Freund's Mathematical Statistics*, 6^{th} Ed., Prentice Hall of India.
5. Mood A.M., Graybill F.A. and Boes D.C. (1974). *Introduction to the Theory of Statistics*, McGraw Hill.
6. Rohatgi, V. K. and Saleh, A.K. Md. E. (2009). *An Introduction to Probability and Statistics*. 2nd Ed., (Reprint) John Wiley and Sons.
7. Snedecor, G.W and Cochran, W.G. (1967). *Statistical Methods*. Iowa State University Press.

PRACTICAL/LABWORK
List of Practicals

1. Unbiased estimators (including unbiased but absurd estimators).
2. Consistent estimators, efficient estimators and relative efficiency of estimators.
3. Cramer-Rao inequality and MVB estimators.
4. Sufficient Estimators: Factorization Theorem, Rao-Blackwell theorem, CompleteSufficient estimators.
5. Lehman-Scheffe theorem and UMVUE.

6. Maximum Likelihood Estimation.
7. Asymptotic distribution of maximum likelihood estimators.
8. Estimation by the method of moments, minimum Chi-square.
9. Type I and Type II errors.
10. Most powerful critical region (NP Lemma).
11. Uniformly most powerful critical region.
12. Unbiased critical region.
13. Power curves.
14. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis.
15. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis.
16. Asymptotic properties of LR tests.

Week-wise Teaching Plan

Week 1-2	Concepts of estimation, unbiasedness, consistency. Including Practical work.
Week 3-4	Concepts of Efficiency. Minimum variance unbiased estimator (MVUE), Cramer-Rao inequality, MVB estimators and their applications. Including Practical work.
Week 5-7	Concepts of Sufficiency. Fisher-Neyman Criterion (statement and applications), Factorization theorem, completeness, Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Including Practical work.
Week 8-9	Methods of estimation: Method of Maximum Likelihood, Method of Moments, method of minimum Chi-square, basic idea of Bayes estimators. Including Practical work.
Week 10-11	Interval estimation - Confidence interval for the parameters of various distributions, Confidence interval for Binomial proportion, Confidence interval for population correlation coefficient for Bivariate Normal distribution, Pivotal quantity method of constructing confidence interval, Large sample confidence intervals. Including Practical work.
Week 12	Principles of test of significance: Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, level of significance, size and power. Including Practical work.
Week 13-15	Best critical region, most powerful test, uniformly most powerful test, uniformly most powerful unbiased critical region (UMPU). Neyman Pearson Lemma and its applications to construct most powerful test. Likelihood ratio test, properties of likelihood ratio tests (without proof). Including Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Estimation: Concepts of estimation, and properties of estimators: unbiasedness,	(i) Class room lectures and discussions. (ii) Data based practical	(i) Participation in class discussion. (ii) To identify the best

	sufficiency, consistency and efficiency. Fisher-Neyman Criterion, Factorization theorem, Rao-Blackwell and Lehmann-Scheffe theorems, Cramer-Rao inequality.	applications of the theoretical concepts.	estimators relevant for given data/sample from real life situations (based on their properties).
II	Methods of Estimation: Method of moments, method of maximum likelihood estimation, method of minimum Chi-square, basic idea of Bayes estimators.	(i) Class room lectures and discussions. (ii) Data based practical applications of the theoretical concepts. (iii) Comparison of results based on different methods.	(i) Participation in class discussion. (ii) To assess the performance of methods of estimation under different real life situations.
I- II			Class test/assignment on first two units
III	Principles of test of significance: Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, level of significance, size and power of the test.	(i) Class room lectures and discussions. (ii) Practical applications based on formulation of hypotheses, determination of size of critical regions and construction of power functions.	(i) Participation in class discussion. (ii) Ability to apply concepts in practical examples.
III	Best critical region, most powerful test, uniformly most powerful test, uniformly most powerful unbiased critical region (UMPU). Neyman Pearson Lemma. Likelihood ratio test.	(i) Class room lectures and discussions. (ii) Practical work.	(i) Participation in class discussion. (ii) Ability to construct best critical regions (tests) for both simple and composite hypotheses for given real life problems.
IV	Interval estimation - Confidence interval for the parameters of various distributions. Pivotal quantity method of constructing confidence interval. Large sample confidence intervals.	(i) Class room lectures and discussions. (ii) Practical work.	(i) Participation in class discussion. (ii) Ability to apply concepts in practical examples.
III-IV			Class test/assignment on last two units.

Keywords: Point estimation, Methods of estimation, Test of significance, Critical region, p value, Interval estimation, Confidence interval.

Bachelor of Science (Hons.) in Statistics
Semester IV
STAT-C-402: Linear Models

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include developing a clear understanding of the fundamental concepts of linear models and a range of associated skills allowing the students to work effectively with them.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- Theory and estimation of Linear Models.
- Gauss-Markov Theorem and its use.
- Distribution of quadratic forms.
- Simple and Multiple linear regression models and their applications.
- Fitting of these models to real or synthetic data, derivation of confidence and prediction intervals, and a sound scientific interpretation of the results.
- Techniques of Analysis of Variance and Covariance under fixed effects model.
- Assessment of the quality of the fit using classical diagnostics, awareness of potential problems (outliers, etc.) and application of remedies to deal with them.

Contents:

UNIT I

Gauss-Markov set up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance. Distribution of quadratic forms.

UNIT II

Regression analysis: Simple Regression analysis, Estimation and hypothesis testing in case of simple and multiple regression analysis, Confidence intervals and Prediction intervals, Concept of model matrix and its use in estimation. Effect of orthogonal columns in the X matrix, Partial F-test and Sequential F-test, Bias in regression estimates.

UNIT III

Analysis of Variance and Covariance: Definition of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data for fixed effect models, analysis of variance in two-way classified data with equal number of observations per cell for fixed effect models.

UNIT IV

Model checking: Prediction from a fitted model, Residuals and Outliers, Lack of fit and pure error, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity, Diagnostics using quantile-quantile plots. Model Building: Techniques for Variable selection. Polynomial Regression models: Orthogonal Polynomials.

SUGGESTED READINGS:

1. Draper, N. R. and Smith, H. (1998): *Applied Regression Analysis*, 3rd Ed., John Wiley and Sons.
2. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2004): *Introduction to Linear Regression Analysis*, 3rd Ed., John Wiley and Sons.
3. Rencher, A. C. and Schaalje, G. B. (2008): *Linear Models in Statistics*, 2nd Ed., John Wiley and Sons.
4. Weisberg, S. (2005): *Applied Linear Regression*, 3rd Ed., John Wiley and Sons.

PRACTICAL/LABWORK
List of Practicals

1. Estimability when X is a full rank matrix.
2. Estimability when X is not a full rank matrix.
3. Distribution of Quadratic forms.
4. Simple Linear Regression.
5. Multiple Regression.
6. Tests for Linear Hypothesis.
7. Bias in regression estimates.
8. Lack of fit.
9. Stepwise regression procedure.
10. Analysis of Variance of a one way classified data.
11. Analysis of Variance of a two way classified data with one observation per cell.
12. Analysis of Variance of a two way classified data with m (> 1) observations per cell.
13. Analysis of Covariance of a one way classified data.
14. Residual Analysis.
15. Orthogonal Polynomials.

Week-wise Teaching Plan:

Week 1	General Linear model-Definition, representations and classification.
Week 2-3	Estimability, Gauss Markov Theorem, Estimation of error variance Concepts of linear parametric functions, estimable functions, Conditions of estimability, Gauss Markov Theorem (for full rank and non-full rank cases) with proof, Concept of number of linearly independent functions. Practical work.
Week 4-5	Distribution of Quadratic forms; Cochran's Theorem and associated theorems with proof. Practical work.
Week 6-7	Regression Analysis-Simple Linear Regression model, Least squares estimation of the parameters, Testing of Hypotheses, Interval estimation, Prediction, Coefficient of Determination, Regression through the origin.

	Practical work.
Week 8-9	Multiple Linear Regression model, Estimation of model parameters, Testing of hypotheses-Global test, Test on Individual Regression Coefficients, Test for subset of Regression coefficients, Extra Sum of Squares method, Partial F test, Sequential test, Orthogonal columns of X matrix, Confidence Intervals. Practical work.
Week 10	Prediction from a fitted model. Practical work.
Week 10	Bias in regression estimates. Practical work.
Week 11	Analysis of Variance and Covariance-Definition of fixed, random and mixed effect models. Practical work.
Week 11-13	Analysis of Variance under Fixed effects model for one way classified data and two way classified data with equal number of observations per cell. Analysis of Covariance under fixed effects model for one way. Practical work.
Week 14	Selection of best linear regression equation by stepwise procedure. Practical work.
Week 14-15	Model Adequacy checking- Residuals and outliers, violation of assumption of Normality, Lack of fit and pure error. Practical work.
Week 15	Polynomial models: Orthogonal Polynomials. Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Theory and estimation of Linear Models.	Class room lectures and discussions.	Participation in class discussion.
I	Gauss-Markov Theorem and its use.	(i) Class room lectures and discussions. (ii) Practical work based on the design and analysis.	(i) Participation in class discussions. (ii) Solution of real life problems using the concepts learnt.
I	Distribution of quadratic forms and Concept of number of linearly independent functions.		
II	Simple and Multiple linear regression models and their applications.		
II	Fitting of these models to real or synthetic data, derivation of confidence and prediction intervals, and a sound scientific interpretation of the results.		
A*	Based on Units I and II.	Class Test/ Assignment Work.	Extent of clarity in theoretical concepts.
III	Techniques of Analysis of Variance and Covariance under fixed effects model.	(i) Class room lectures and discussions.	(i) Participation in class discussions. (ii) Solution of real life
IV	Assessment of the quality of the		

	fit using classical diagnostics, awareness of potential problems (outliers, influential observations, etc.) and application of remedies to deal with them.	(ii) Practical work based on the design and analysis.	problems using the concepts learnt.
B*	Based on Units III to IV.	Class Test/ Assignment Work.	Extent of clarity in theoretical concepts.
C	Application of Linear Models (optional).	Project work	Ability to apply concepts learnt under the course to real life problems. (Use secondary data only)

* As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Analysis of Variance and Covariance, Gauss-Markov Theorem, Regression Analysis, Lack of fit and pure error, Homoscedasticity and Collinearity, Orthogonal Polynomials.

Bachelor of Science (Hons.) in Statistics

Semester IV
STAT-C-403: Statistical Quality Control

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include:
- This course will help students to learn techniques and approach of SQC being used in industry to manufacture goods and services of high quality at low cost.
- This course will also give exposure to Six sigma and Index Numbers.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- Statistical process control tools- Control charts for variables, attributes.
- Statistical product control tools- Sampling inspection plans.
- Overview of Six sigma- Lean manufacturing, TQM.
- Overview of Six sigma training plans, VOC, CTQ.
- Weighted and Unweighted Index Numbers.
- Base shifting, splicing and deflating of Index Numbers.

Contents:

UNIT I

Quality: Definition, dimensions of quality, its concept, application and importance. Introduction to Process and Product Controls. Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation. Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM). Organizational Structure and Six Sigma training plans- Selection Criteria for Six-Sigma roles and training plans. Voice of customers (VOC): Importance and VOC data collection. Critical to Quality (CTQ), Introduction to DMAIC.

UNIT II

Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts, Control charts for variables: $\bar{X}$& R-chart, $\bar{X}$& s-chart. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Rational Sub-grouping. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability.

UNIT III

Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.

UNIT IV

Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa. Consumer price index numbers. Compilation of indices, base shifting, splicing and deflating of index numbers. Uses and limitations of index numbers.

SUGGESTED READINGS:

1. Ehrlich, H. B. (2002). *Transactional Six Sigma and Lean Servicing*, 2nd Ed., St. Lucie Press.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002). *Fundamentals of Statistics*, Vol. I & II, 8th Ed., The World Press, Kolkata.
3. Gupta, S.C. and Kapoor, V.K. (2014). *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand.
4. David, H. (1995). *ISO Quality Systems Handbook*, 2nd Ed., Butterworth Heinemann Publication.
5. Montogomery, D. C. (2009). *Introduction to Statistical Quality Control*, 6th Ed., Wiley India Pvt. Ltd.

PRACTICAL/LAB WORK
List of Practicals

Mode of Conducting Practical Examination: The Students should encouraged to perform practical problems on computers using whatsoever software/package far as possible.

1. Construction and interpretation of statistical control charts for
   a) $\bar{X}$& R-chart
   b) $\bar{X}$& s-chart
   c) np-chart
   d) p-chart
   e) c-chart
   f) u-chart
2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves.
3. Calculation of process capability and comparison of 3-sigma control limits with specification limits.
4. Calculate price and quantity index numbers using simple and weighted average of price relatives.
5. To Calculate the Chain Base Index numbers.
6. To Calculate the Consumer Price Index numbers.
7. Practical based on shifting of base, splicing and deflating of index numbers.

Week-wise Teaching Plan

Week- 1	Introduction to quality dimensions of quality, Its concept, application and importance.
Week -2	Process and product control, Seven tools of SPC, Chance and Assignable causes of quality variation.
Week 3-5	Statistical Control Charts- Statistical basis of 3-σ Control charts, Control charts for variables: $\bar{X}$& R-chart, $\bar{X}$& s-chart. Rational Sub-grouping, Revised and Modified Control Limits. Practical work.
Week 5-7	Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability. Practical work.
Week 7-9	Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables. Practical work.
Week 10	Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM).
Week 10	Organizational Structure and Six Sigma training plans.
Week 11-12	Overview of Selection Criteria for Six-Sigma roles and training plans. Voice of customers (VOC). Critical to Quality (CTQ). Introduction to DMAIC.
Week 12-13	Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Average of Price Relatives. Practical work.
Week 13-14	Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa. Criteria of Good Index Numbers. Consumer price index numbers. Practical work.
Week 15	Base shifting, splicing and deflating of index numbers. Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Introduction to Quality. Statistical process control tools, causes of variation. Overview of Six sigma- Lean manufacturing, TQM Six sigma training plans, VOC, CTQ. Introduction of DMAIC.	(i) Class room lectures and discussions.	Participation in class discussion.
II	Statistical process control tools- Control charts for variables, attributes.	(i) Class room lectures and discussions.	Participation in class discussion. Problem solving, Analyse and

		(ii) Practical problems from the list of practical.	Interpret the results.
A*	Understanding basic concepts and control charts.	Class Test/ Assignment work	Extent of clarity of theoretical concepts studied in the course.
III	Statistical product control tools- Sampling inspection plans, Dodge and Romig plans.	(i) Class room lectures and discussions. (ii) Practical problems from the list of practical.	Participation in class discussion. Problem solving, Analyse and Interpret the results.
IV	Construction of index numbers and problems thereof for weighted and unweighted index numbers. Criteria of Good Index Numbers. Base shifting, splicing and deflating of index numbers.	(i) Class room lectures and discussions. (ii) Practical problems from the list of practical.	Participation in class discussion. Problem solving, Analyse and Interpret the results.
B*	Understanding of complete course.	Class Test/ Assignment work	Extent of clarity of theoretical concepts studied in the course.
C	Application of statistical quality control. (optional)	Project Work and its presentation.	Ability to apply concepts of quality control, practical handling, understanding and giving solutions to a problem.

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Statistical process/product control, Process capability, Control charts, Three sigma and specification limits, Single and Double sampling plans, Index number construction.

Bachelor of Science (Hons.) in Statistics
Semester V
STAT-C-501: Stochastic Processes and Queuing Theory

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include:
- To define, design and model;
- To analyze;
- To identify the real life applications of stochastic processes.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- The fundamental concepts of stochastic processes.
- Tools needed to analyze stochastic processes.
- Markov processes and Markov chains.
- Stability of Markov chains.
- Poisson process and its variations.
- Queuing systems.
- Random walk and ruin theory.

Contents:

UNIT I

Probability Distributions: Generating functions, Bivariate probability generating functions. Stochastic Process: Introduction, Stationary Process.

UNIT II

Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system.

UNIT III

Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, pure death process.

UNIT IV

Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof). Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.

SUGGESTED READINGS:

1. Basu, A.K. (2005). *Introduction to Stochastic Processes*, Narosa Publishing.

2. Bhat,B.R. (2000). *Stochastic Models: Analysis and Applications*, New Age International Publishers.
3. Feller, W. (1968). *Introduction to probability Theory and Its Applications*, Vol I, 3rd Ed., Wiley International.
4. Medhi, J. (2009). *Stochastic Processes*, New Age International Publishers.
5. Taha, H. (1995). *Operations Research: An Introduction*, Prentice- Hall India.

PRACTICAL/LAB WORK
List of Practicals:

Mode of Conducting Practical Examination: The students should be encouraged to perform practical problems on computers using whatsoever software/package as far as possible.

1. Applications of Partial Fraction Theorem.
2. Problems based on (covariance) stationary processes.
3. Markov Chains:
   a) Simulation of Markov chains and Calculation of transition probability matrices.
   b) Stability of Markov chains.
   c) To check whether the given chain is irreducible or not.
   d) Computation of probabilities in case of generalizations of independent Bernoulli trials.
4. Simulation and applications of Poisson processes.
5. Calculation of probabilities for given birth and death processes.
6. Calculation of probabilities for ruin problems.
7. Problems based on (M/M/1) queuing models.

Week-wise Teaching Plan

Week 1-2	Probability Distributions: Generating functions, Bivariate probability generating functions.
Week 3-4	Stochastic Process: Introduction, Stationary Process.
Week 5-6	Markov Chains: Definition of Markov Chain with examples, transition probability matrix, order of Markov chain, Markov chain as graphs.
Week 7-8	Higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, Stability of Markov system.
Week 9-11	Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, Pure birth process, Yule Furry process, birth and death process, pure death process.
Week 12-13	Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof).
Week 14-15	Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Determination of $\{p_k\}$ from a given generating function (an application of partial fraction theorem).	(i) Class room lectures and discussions. (ii) Practical work	Participation in class discussion.
I	Generating function of sum of a random number of discrete random variables.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
I	The fundamental concepts of stochastic processes.	Class room lectures and discussions.	Participation in class discussion.
I	Tools needed to analyze stochastic processes.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
II	Markov chains with examples.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
II	Higher transition probabilities.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
II	Classification of states and chains.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
II	Reducible and irreducible Markov chains.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
II	Stability of Markov chains.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
			Class test/assignment on first two units
III	Poisson process: postulates and Properties.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
III	Birth and death processes as application of Poisson process.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
III	Expected population size and its	(i) Class room	Participation in class

	variance under linear growth,birth and death process.	lectures and discussions. (ii) Practical work.	discussion.
IV	Queuing systems.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
IV	Random walk and ruin theory.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
			Class test/assignment on last two units.

Keywords: Probability Distributions, Markov Chain, Poisson process, Random walk, Queuing systems, Ruin Problem.

Bachelor of Science (Hons.) in Statistics

Semester V
STAT-C-502: Statistical Computing Using C/C++ Programming

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include:
- To understand computer programming and its roles in problem solving.
- To understand basic data structures and develop logics which will help them to create well-structured programs using C language.
- Learning the basic programming language will help students to easily switch over to any other language in future.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- Various data types, operators, library functions, Input/Output operations.
- Decision making and branching and looping.
- Arrays, Character and strings.
- User- defined functions, recursion functions.
- Storage class of Variables.
- Pointers.
- Pointers and arrays, arrays of pointers, pointers as function arguments, functions returning pointers.
- Structure, array of structures, structure pointers.
- Dynamic memory allocation functions.
- Pre-processors: Macro substitution, macro with argument.
- File inclusion in C/C++, I/O operations on files.

Contents:

UNIT I

History and importance of C/C++. Components, basic structure programming, character set, C/C++ tokens, Keywords and Identifiers and execution of a C/C++ program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, Symbolic Constants, overflow and underflow of data.Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement, operators, precedence of operators in arithmetic, relational and logical expression. Implicit and explicit type conversions in expressions, library functions. Managing input and output operations: reading and printing formatted and unformatted data.

UNIT II

Decision making and branching - if…else, nesting of if…else, else if ladder, switch, conditional (?) operator. Looping in C/C++: for, nested for, while, do…while, jumps in and out of loops. Arrays: Declaration and initialization of one-dim and two-dim arrays. Character arrays and strings: Declaring and initializing string variables, reading and writing strings from Terminal (using scanf and printf only).

UNIT III

User- defined functions: A multi -function program using user-defined functions, definition of functions, return values and their types, function prototypes and calls. Category of Functions : no arguments and no return values, arguments but no return values , arguments with return values, no arguments but returns a value, functions that return multiple values. Recursion function. Passing arrays to functions, Storage class of Variables.

UNIT IV

Pointers: Declaration and initialization of pointer variables, accessing the address of a variable, accessing a variable through its pointer, pointer expressions, pointer increments/decrement and scale factor. Pointers and arrays, arrays of pointers, pointers as function arguments, functions returning pointers Structure: Definition and declaring, initialization, accessing structure members, copying and comparison of structure variables, array of structures, structure pointers. Dynamic memory allocation functions: malloc, calloc and free. Pre-processors: Macro substitution, macro with argument File inclusion in C/C++: Defining and opening a file (only r, w and a modes), closing a file, I/O operations on files- fscanf and fprintf functions.

SUGGESTED READINGS:

1. Balagurusamy, E. (2011). *Programming in ANSI C*, Ed., and Tata McGraw Hill.
2. Gottfried, B.S. (1998). *Schaum's Outlines: Programming with C,* 2nd Ed., Tata McGraw Hill
3. Kernighan, B.W. and Ritchie, D. (1988). *C Programming Language*, 2nd Ed., Prentice Hall.

PRACTICAL/ LAB WORK

List of Practicals:

1. Plot of a graph y = f(x).
2. Roots of a quadratic equation (with imaginary roots also).
3. Sorting of an array and hence finding median.
4. Mean Median and Mode of a Grouped Frequency Data.
5. Variance and coefficient of variation of a Grouped Frequency Data.
6. Preparing a frequency table.
7. Value of n! using recursion.
8. Random number generation from uniform, exponential, normal (using CLT) and gamma distribution calculate sample mean and variance and compare with population parameters.
9. Matrix addition, subtraction, multiplication Transpose and Trace.

10. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit.
11. Chi-square contingency table.
12. t-test for difference of means.
13. Paired t-test.
14. F-ratio test.
15. Multiple and Partial correlation.
16. Compute ranks and then calculate rank correlation (without tied ranks).
17. Fitting of lines of regression.

Week-wise Teaching Plan

Week 1-2	Overview of C, Constants, Variables and Data Types.
Week 2-3	Operators and Expressions.
Week 4	Managing Input and Output Operations.
Week 5-6	Decision Making and Branching, Develop programs to do statistical computing.
Week 6-7	Decision Making and Looping, Develop programs to do statistical computing.
Week 8-9	Arrays, Develop programs to do statistical computing related to arrays, matrices etc.
Week 10	Character Arrays, Strings.
Week 11	File Management in C, Develop programs to do statistical computing using files input/output files.
Week 11-13	User- defined Functions, Develop programs to do statistical computing using user defined functions, recursion.
Week13-14	Structure and Pointers, Develop programs to do statistical computing with the concept of structures and pointers.
Week 15	Dynamic Memory Allocation and the Preprocessor.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Various data types, operators, library functions, Input/ Output operations.	(i) Class room lectures and discussions. (ii) Solving of arithmetic expressions involving all types of operators.	Participation in class discussion. Understanding the logic of expression solving hierarchy.
II	Decision making and branching and looping.	(i) Class room lectures and discussions. (ii) Writing of small program segments and solving exercise	Participation in class discussion.

		questions from suggested readings.	Understanding the logic of expression solving hierarchy with decision making and loops.
II	Arrays, Character and strings.	(i) Class room lectures and discussions. (ii) Writing full statistical computing programs mentioned in the list of practical and running on Computer with data.	Participation in class discussion. Ability to write full program with a dry run and error free program on computer.
A*	Understanding basic concepts and writing of programs using arrays.	Class Test/ Assignment work.	Extent of clarity of theoretical concepts studied in the course.
III	User- defined functions, recursion functions. Storage class of Variables.	(i) Class room lectures and discussions. (ii) Writing full statistical computing programs mentioned in the list of practical and running on Computer with data.	(i) Participation in class discussion. (ii) Ability to write full program with a dry run and error free program on computer.
IV	Pointers.	(i) Class room lectures and discussions. (ii) Writing of small program segments and solving exercise questions from suggested readings.	Participation in class discussion. Understanding the concept of pointers.
IV	Pointers and arrays, arrays of pointers, pointers as function arguments, functions returning pointers.	(i) Class room lectures and discussions. (ii) Writing full statistical computing programs mentioned in the list of practical and running on Computer with data.	(i) Participation in class discussion. (ii) Ability to write program pointers with a dry run and error free program on computer.
IV	Structure, array of structures, structure pointers. Dynamic memory allocation functions.	(i) Class room lectures and discussions. (ii) Writing of small program segments and solving exercise questions from suggested readings.	(i) Participation in class discussion. (ii) Understanding the concept of pointers in relation to structures and memory allocation.

IV	Pre-processors: Macro substitution, macro with argument. File inclusion in C/C++, I/O operations on files.	(i) Class room lectures and discussions. (ii) Writing of small program segments and solving exercise questions from suggested readings.	(i) Participation in class discussion. (ii) Ability to write C programs using files and run on computer.
B*	Understanding basic concepts and writing of programs using arrays, user-defined functions, pointers etc.	Class Test/ Assignment work.	Extent of clarity of theoretical concepts studied in the course.
C*	Ability to write and run complete error free program on computer.	Practical test on computers.	Practical handling of running understanding and rectifying errors in the program.

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: C programming, Data types, Loops, Header files, Pre-processor directives, storage classes, Macros, Functions and arguments arrays, Pointers, Dynamic memory allocation.

Bachelor of Science (Hons.) in Statistics
Semester VI
STAT-C-601: Design of Experiments

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include:
- To design and conduct experiments.
- To analyze and interpret data.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- The fundamental concepts of design of experiments.
- Introduction to planning valid and economical experiments within given resources.
- Completely randomized design.
- Randomized block design.
- Latin square design.
- Balanced incomplete block design.
- Full and confounded factorial designs with two and three levels.
- Fractional factorial designs with two levels.

Contents:

UNIT I

Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) -layout, model and statistical analysis, relative efficiency, analysis with missing observations.

UNIT II

Incomplete Block Designs: Balanced Incomplete Block Design (BIBD)-parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD, Intra Block analysis, complimentary BIBD, Residual BIBD, Dual BIBD, Derived BIBD.

UNIT III

Factorial experiments: Concepts, notations and advantages, 2^2, $2^3 \ldots 2^n$ and 3^2 factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 5$), 3^2 and 3^3.Factorial experiments in a single replicate.

UNIT IV

Fractional factorial experiments: Construction of one-half and one-quarter fractions of 2^n ($n \leq 5$) factorial experiments, Alias structure, Resolution of a design.

SUGGESTED READINGS:

1. Cochran, W.G. and Cox, G.M. (1959). *Experimental Design*. AsiaPublishing House.

2. Das., M.N. and Giri, N.C. (1986). *Design and Analysis of Experiments*. Wiley Eastern

3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005). *Fundamentals of Statistics*. Vol. II, 8thEd. World Press, Kolkata.

4. Kempthorne, O. (1965). *The Design and Analysis of Experiments*. John Wiley.

5. Montgomery, D. C. (2008). *Design and Analysis of Experiments*. John Wiley.

PRACTICAL/LAB WORK
List of Practicals:

1. Analysis of a CRD with equal and unequal replicates.
2. Analysis of RBD.
3. Analysis of LSD.
4. Analysis of RBD with one missing observation.
5. Analysis of LSD with one missing observation.
6. Intra block analysis of BIBD.
7. Intra block analysis of a symmetric BIBD.
8. Analysis of 2^2 and 2^3 factorial in CRD, RBD and LSD.
9. Analysis of a 3^2 factorial in CRD and RBD.
10. Analysis of a completely confounded two level factorial design in 2 blocks.
11. Analysis of a completely confounded two level factorial design in 4 blocks.
12. Analysis of a partially confounded two level factorial design.
13. Analysis of a single replicate of a 2^n design.
14. Analysis of one half fraction of 2^n factorial design.
15. Analysis of one quarter fraction of 2^n factorial design.

Week-wise Teaching Plan

Week 1	Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks.
Week 2-3	Basic Designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD)-layout, model, statistical analysis, advantages and their applications. Practical work.
Week 3	Relative efficiencies of RBD compared to CRD, LSD compared to CRD, LSD compared to RBD taking rows as blocks, LSD compared to RBD taking columns as blocks. Practical work.
Week 4	Missing Plot technique (for both RBD and LSD) for one missing observation only, Variance of the difference between two estimated treatment effects out of which one has the missing observation (for both RBD and LSD). Practical work.
Week 5	Balanced Incomplete Block Design (BIBD): parameters, relationships among its parameters, incidence matrix and its properties.
Week 5	Intra Block analysis, Variance of the difference between two estimated treatment effects, Relative efficiency of BIBD compared to RBD. Practical

	work.
Week 6	Definition and Properties of Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD. Practical work.
Week 7	Construction of complimentary BIBD, Residual BIBD, Dual BIBD, Derived BIBD.
Week 8	Factorial Experiments: Advantages over simple experiments, notations, concepts of main effects and interaction effects.
Week 9	2^n Factorial Designs -Standard order for treatment combinations, Main effects and interactions, Yates' Algorithm, Design and analysis. Practical work.
Week 10	3^n Factorial Designs - Standard order for treatment combinations, Main effects and interactions, Yates' Algorithm, Design and analysis (n=2).Practical work.
Week 11-13	Total and Partial confounding- Confounding 2^n ($n \leq 5$) in two blocks and four blocks, Confounding the 3^n ($n \leq 3$) in three blocks, identification of the confounded effects for both 2^n ($n \leq 5$) and 3^n ($n \leq 3$) factorial designs. Practical work.
Week 13	Analysis of a single replicate. Practical work.
Week 14	Fractional Factorial Designs: Introduction, Concepts - Word, Defining Relation, Principal and Complementary Fractions, Aliases, Alias Structure, Resolution of a Design, Construction of Resolution III, IV and V Designs.
Week 15	Construction of one half and one-quarter fractions of 2^n ($n \leq 5$). Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	The fundamental concepts of design of experiments.	Class room lectures and discussions.	Participation in class discussion.
I	Introduction to planning valid and economical experiments within given resources.	Class room lectures and discussions.	Participation in class discussion.
I	Completely randomized designs.	(i) Class room lectures and discussions. (ii) Practical work based on the design and analysis.	(i) Participation in class discussion. (ii) Identification of design, model, formulation of null hypothesis, appropriate analysis, interpretation of results and conclusion.
I	Randomized block design.		
I	Latin square design.		
A*	Understanding of fundamentals and design and analysis of basic	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.

	designs.		
II	Balanced incomplete block design.	(i) Class room lectures and discussions. (ii) Practical work based on the design and analysis.	(i) Participation in class discussion. (ii) Identification of design, model, formulation of null hypothesis, appropriate analysis, interpretation of results and conclusion.
III	Full and confounded factorial designs with two and three levels.		
IV	Fractional factorial designs with two levels.		
B*	Understanding of BIBD, Full and confounded factorial and Fractional factorial designs.	Class Test/ Assignment work	Extent of clarity in theoretical concepts.
C	Application of design of experiments. (optional)	Project work and its presentation.	Ability to apply concepts of designing and analysing experiments.

* As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Design of experiments, Completely randomized designs, Latin square design, Balanced incomplete block design, Fractional experiments, Fractional factorial experiments, confounding, Resolution of design.

Bachelor of Science (Hons.) in Statistics

Semester VI

STAT-C-602: Multivariate Analysis and Non-Parametric Methods

Credits:6 **Marks:150**

Course Objectives:

The learning objectives include:

- Study of theoretical concepts of Bivariate Normal and Multivariate Normal Distributions along with their properties.
- Analyze multivariate data.
- Application of Wald's SPRT and Non-Parametric methods of testing of hypothesis.

Course Learning Outcomes:

On completion of the course, students should have achieved the following:

- The understanding of basic concepts associated with Multivariate Normal Distributions and their properties with special emphasis on Bivariate Normal Distribution.
- Analyzing Multivariate data using data reduction techniques like Principal Component Analysis, Factor Analysis.
- Classification method namely Discriminant Analysis.
- Application of Wald's SPRT for testing simple null hypothesisvs simple alternative hypothesis along with the study of the O.C. function and the ASN function for various underlying continuous and discrete distributions.
- Testing of hypothesis using Non-Parametric tests like Median test, Runs test, U test, Kruskal Wallis test etc. and ability to use them judiciously for the testing of given data.

Contents:

UNIT I

Bivariate Normal Distribution (BVN): pdf of BVN, properties of BVN, marginal and Conditional pdf of BVN. Multivariate Data: Random Vector: Probability mass/density functions, Distribution Function, Mean vector, Dispersion matrix, Marginal distributions, Conditional distributions.

UNIT II

Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance-covariance matrix. Multiple and partial correlation coefficient and their properties. Introduction to discriminant Analysis, Principal Components Analysis and Factor Analysis.

UNIT III

Sequential Analysis: Sequential probability ratio test (SPRT) for simple v/s simple Hypotheses. Fundamental relations among α, β, A and B, determination of A and B in Practice. Wald's fundamental identity and the derivation of operating characteristics (OC) and average sample number (ASN) functions, examples based on normal, Poisson, binomial and exponential distributions.

UNIT IV

Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, Kolmogorov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.

SUGGESTED READINGS:

1. Anderson, T.W. (2003). *An Introduction to Multivariate Statistical Analysis*, 3rd Ed., John Wiley& Sons.
2. Arora, S.and Bansi, L. (1968). *New Mathematical Statistics*, 1st Ed., Vanita Printers.
3. Gibbons, J. D. and Chakraborty, S. (2003). *Non-Parametric Statistical Inference*. 4thEd., Marcel Dekker, CRC.
4. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2005). *An Outline of Statistical Theory*, Volume II, World Press.
5. Gupta, S.C. and Kapoor, V.K. (2014). *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand.
6. Johnson, R.A. and Wichern, D.W. (2007). *Applied Multivariate Analysis*, 6th Ed., Prentice Hall.
7. Kshirsagar, A.M. (1972). *Multivariate Analysis*, 1st Ed., Marcel Dekker.
8. Muirhead, R.J. (1982). *Aspects of Multivariate Statistical Theory*, John Wiley.
9. Mukhopadhyay, P. (2015). *Mathematical Statistics.*
10. Rao, C. R. (2000). *Linear Statistical Inference,* John Wiley & Sons.
11. Siegel, S. and Castellan, N.J. (1988). *Non-Parametric Statistics for the Behavioral Sciences*, 2nd Ed., International Edition.
12. Siegel, S. (1956). *Non-Parametric Statistics for the Behavioral Sciences*, McGraw Hill.

PRACTICAL/LAB WORK
List of Practicals:

1. Bivariate Normal Distribution and it’s properties.
2. Multivariate Normal Distribution and it’s properties.
3. Partial Correlation Coefficient.
4. Multiple Correlation Coefficient.
5. Plane of Regression.
6. Principal Component Analysis.
7. Discriminant analysis.
8. Factor Analysis.
9. SPRT Procedure and Graphical representation of decision lines, acceptance and rejection regions.

10. ASN function and ASN curve.
11. OC function and OC curve.
12. Test for randomness based on total number of runs.
13. Kolmogorov Smirnov test for one sample.
14. Sign test: one sample, two sample, large samples.
15. Wilcoxon-Mann-Whitney U – test.
16. Kruskal - Wallis test.
17. Wald- Wolfowitz test.
18. Median Test.

Week-wise Teaching Plan

Week 1	Basic Concepts: random vector, pdf, mean vector, dispersion matrix, distribution function, marginal and conditional distribution of random vector.
Week 2-3	Bivariate Normal Distribution (BVN), Marginal and Conditional Distribution of BVN, mgf of BVN. Practical work.
Week 4-6	Multivariate Normal Distribution (MVN), Marginal and Conditional Distribution of MVN, mgf of MVN, Statistical Independence, Distribution of linear combination of normally distributed variates, Characteristic function, Practical work.
Week 7	Sampling Distribution of X and S.
Week 8	Multiple and Partial Correlation Coefficient and Plane of Regression. Practical work.
Week 9-11	Data Reduction and Classification Techniques: Principal Component Analysis, Factor Analysis, Discriminant Analysis. Practical work.
Week 12-13	SPRT for simple vs. Simple hypotheses, Relations among α, β, A and B. Determination of A and B in practice, Wald's Identity, ASN and OC functions with examples based on Normal (for Mean when Variance specified and for Variance when Mean specified), Exponential, Binomial and Poisson distributions. Practical work.
Week 14-15	Nominal, Ordinal Interval, Ratio scales of measurement, Advantages and disadvantages of non- parametric tests vis a vi Parametric tests, Theory and application of Non-Parametric Tests: - Kolmogorov-Smirnov one sample test, One sample run test for randomness, Sign test, Median Test, Mann-Whitney U test, Wald Wolfowitz Run test, Kruskal Wallis test. Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Function, marginal and conditional The fundamental concepts related to random variable, mean vector, dispersion matrix, and	Class room lectures and discussions.	Participation in class discussion.

	characteristic distributions.		
I	Bivariate Normal Distribution and its Properties.	(i) Class room lectures and discussions. (ii) Practical work based on properties of BVN.	(i) Participation in class discussion. (ii) Doing assignments comprising of problems based on BVN.
II	Multivariate Normal Distribution and its Properties.	(i) Class room lectures and discussions. (ii) Practical work based on properties of MVN.	(i) Participation in class discussion. (ii) Doing assignments comprising of problem based on MVN.
II	Sampling Distribution of $\bar{X}$ and S.	Class room lectures and discussions.	Participation in class discussion.
II	Multiple and Partial Correlation Coefficient and Plane of Regression.	(i) Class room lectures and discussions. (ii) Practical work based on computation and interpretation of multiple and partial correlation coefficients for more than 3 variables, obtaining equations of planes of regression and use them for prediction.	Participation in class discussion.
A*	Understanding of fundamentals and properties of BVN and MVN, multiple and partial correlation coefficients with related problems.	Class Test/ Assignment work.	Extent of clarity in Theoretical concepts and their applications.
III	Wald's SPRT procedure for simple vs. simple hypotheses, ASN and OC functions.	Class room lectures and discussions. Practical work based on: - Construction of SPRT for testing the hypotheses, ASN and OC functions and their graphical representations.	(i) Participation in class discussion. (ii) Doing assignments comprising of problems based on SPRT, ASN and OC functions for Normal, Binomial, Poisson and Exponential
IV	Nominal, Ordinal, Interval and Ratio scales of measurement.	Class room lectures and discussions.	Participation in class discussion.
IV	Knowledge and Understanding of Non-Parametric tests.	(i) Class room lectures and discussions. (ii)Practical work based on formulation of hypotheses,	(i) Participation in class discussion. (ii) Doing assignments comprising of

		application of an appropriate NP test and interpretation of results.	problems based on application of NP tests to the real-life data.
B*	Understanding of SPRT, OC and ASN function, Non-Parametric tests.	Class Test/ Assignment Work.	Extent of clarity in theoretical concepts and their applications.

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Bivariate Normal Distribution, Multivariate Normal Distribution, Principal Components Analysis and Factor Analysis, Discriminant Analysis, Sequential probability ratio test, Operating characteristics (OC), Average sample number (ASN) functions, Non-Parametric tests.

DSE Papers in Statistics

Bachelor of Science (Hons.) in Statistics

Semester-V

STAT-DSE – 1 (A): Time Series Analysis

Credit –6 **Marks: 150**

Course Objectives:

The course objectives include:

- Understanding of the process generating a time series.
- Forecasting future values of the observed series.

Course Learning Outcomes:

After completing this course, the students will possess skills to understand the components and forecast values of a time series at future time points.

Contents:

UNIT I

Introduction to times series data, application of time series from various fields, Components of a times series, Decomposition of time series. Estimation of trend by free hand curve method, method of semi averages, fitting mathematical curve and growth curves. Estimation of trend by method of moving averages. Detrending: effect of elimination of trend on other components of a time series.

UNIT II

Seasonal Component: Estimation of seasonal component by the methods of - simple averages, Ratio to Trend, Ratio to Moving Averages and Link Relative method. Deseasonalization. Cyclic Component: Harmonic Analysis.

UNIT III

Random Component: Variate difference method. Stationary Time series: Weak stationarity, autocorrelation function and the correlogram. Some Special Processes: Moving-average (MA) process and Autoregressive (AR) processes. Estimation of the parameters of AR (1) and AR (2). Autocorrelation functions of AR(1) and AR(2) processes.

UNIT IV

Introduction to methods of Forecasting a time series. Forecasting by the methods of Exponential smoothing. Introduction to ARMA and ARIMA models. Short-term forecasting methods Brown's discounted regression, Box-Jenkins method and Bayesian forecasting.

SUGGESTED READINGS:

1. Kendall, M.G. (1976). *Time Series*, 2nd Ed., Charles Griffin and Co Ltd., London and High Wycombe.
2. Chatfield, C. (1980). *The Analysis of Time Series –An Introduction*, Chapman & Hall.

3. Mukhopadhyay, P. (2011). *Applied Statistics*, 2nd Ed., Revised reprint, Books and Allied
4. Goon, A. M., Gupta, M. K. and Dasgupta, B. (2003). *Fundamentals of Statistics*, 6th Ed., Vol II Revised,Enlarged.
5. Gupta, S.C. and Kapoor, V.K. (2014). *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand and Sons.
6. Montgomery, D. C. and Johnson, L. A. (1967). *Forecasting and Time Series Analysis*, 1st Ed. McGraw-Hill, New York.

PRACTICAL / LAB WORK
List of Practicals:

1. Fitting and plotting of modified exponential curve by different methods.
2. Fitting and plotting of Gompertz curve by different methods.
3. Fitting and plotting of logistic curve by different methods.
4. Fitting of trend by Moving Average Method for given extent and for estimated extent.
5. Fitting of trend by Spencer's 15-point and 21-point formulae.
6. Measurement of Seasonal indices:
   a) Simple Averages method
   b) Ratio-to-Trend method
   c) Ratio-to-Moving Average method
   d) Link Relative method
7. Estimation of variance of the random component by variate difference method.
8. Forecasting by exponential smoothing.
9. Plotting of Correlogram of moving average.

(May be done using EXCEL, SPSS, R, Calculators)

Week-Wise Teaching Plan

Week 1	Introduction to times series data, application of time series from various fields, Components of a times series, Decomposition of time series.
Week 2-3	Estimation of trend by free hand curve method, method of semi averages, fitting mathematical curve and growth curves. Practical work.
Week 3-4	Estimation of trend by method of moving averages. Detrending: Effect of elimination of trend on other components of a time series. Practical work.
Week 5-7	Seasonal Component: Estimation of seasonal component by the methods of: Simple averages, Ratio to Trend, Ratio to Moving Averages and Link Relative method. Deseasonalization. Practical work.
Week 8-9	Cyclic Component: Harmonic Analysis. Random Component: Variate difference method. Practical work.
Week 9-11	Stationary Time series: Weak stationarity, autocorrelation function and the correlogram. Some Special Processes: Moving-average (MA) process and Autoregressive (AR) processes. Estimation of the parameters of AR (1) and AR (2). Autocorrelation functions of AR(1) and AR(2) processes. Practical work.
Week 11-12	Introduction to methods of Forecasting a time series. Forecasting by the

	methods of Exponential smoothing. Practical work.
Week 12	Introduction to ARMA and ARIMA models.
Week 13	Short-term forecasting method: Brown's discounted regression.
Week 14	Short-term forecasting method: Box-Jenkins method.
Week 15	Short-term forecasting method: Bayesian forecasting.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Concept and application of time series.	Class room lectures, presentations and discussions.	Participation in class discussion.
I	Components and decomposition of time series.	Class room lectures and discussions.	Participation in class discussion.
I	Trend component.	(i) Class room lectures and discussions. (ii) Practical work.	(i) Participation in class discussion. (ii) Appraisal of different components.
II	Seasonal component.		
II	Cyclical component.		
III	Random component		
A*	Understanding of basic concept of time series and its components.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.
III	Stationary time series.	(i) Class room lectures and discussions. (ii) Practical work.	(i) Participation in class discussion. (ii) Appraisal of different forecasting methods.
III	Some special processes.		
IV	Introduction to methods of forecasting a times series.		
	Forecasting by methods of exponential smoothing.		
	Short term forecasting.		
B*	Understanding of stationary time series, special processes and forecasting methods.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Component and Decomposition of time series, Autocorrelation function and the correlogram, Moving-average (MA) process and Autoregressive (AR) processes, forecasting a time

Bachelor of Science (Hons.) in Statistics

Semester V

STAT-DSE-1(B): Demography and Vital Statistics

Credits: 6 **Marks: 150**

Course Objectives:

The learning objectives include:

- To collect valid Demographic data using different methods.
- To learn basic measures of Mortality, Fertility and Population Growth.
- To construct life tables.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Distinction between Vital Statistics and Demography.
- Errors in Demographic data.
- To check the completeness of registration data using Chandrasekaran-Deming formula.
- Use of Myer's and UN indices in evaluating age data.
- Use of Balancing Equations.
- Population Composition and Dependency Ratio.
- Sources of data collection on Vital Statistics and errors therein.
- Measurement of Population.
- Distinction between Rate and Ratio.
- Basic measures of Mortality.
- Concepts of Stable and Stationary Populations.
- Concept of Life Tables, their construction and uses.
- Concept of Abridged life tables and their construction by Reed and Merrell method, Greville's method and King's Method.
- Basic measures of Fertility.
- Measures of Population Growth.

Contents:

UNIT I

Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekaran-Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio.

UNIT II

Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates.

UNIT III

Stationary and Stable population, Central Mortality Rates and Force of Mortality. Life(Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables.

UNIT IV

Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's Method. Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

SUGGESTED READINGS:

1. Biswas, S. (1988). *Stochastic Processes in Demography & Application*, Wiley Eastern Ltd.
2. Croxton, Fredrick, E. Cowden, Dudley J. and Klein, S. (1973). *Applied General Statistics*, 3rd Ed., Prentice Hall of India Pvt. Ltd.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008). *Fundamentals of Statistics*, Vol. II, 9thEd., World Press.
4. Keyfitz, N. and Beekman,J.A. (1985). *Demography through Problems*. S-Verlag, New York.
5. Mukhopadhyay, P. (1999). *Applied Statistics*, Books and Allied (P) Ltd.

PRACTICAL/LAB WORK
List of Practicals:

1. To calculate CDR and Age Specific death rate for a given set of data.
2. To find standardized death rate by: (i) Direct method (ii) Indirect method.
3. To construct a complete life table.
4. To fill in the missing entries in a life table.
5. To calculate probabilities of death at pivotal ages and use it construct abridged life table using: (i) Reed-Merrell Method, (ii) Greville's Method and (iii) King's Method.
6. To calculate CBR, GFR, SFR, TFR for a given set of data.
7. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data.
8. Calculate GRR and NRR for a given set of data and compare them.

Week-wise Teaching Plan

Week 1	Meaning of Demography and Population Statistics, Coverage and Content Errors in Demographic data, Sampling and Non-sampling errors, Use of Balancing Equations.
Week 2-3	Chandrasekran-Deming formula, Population Composition, Dependency Ratio Errors in Age data, Evaluation of Age data, Myer's and UN Indices.
Week 4	Adjustment of Age data, Meaning of Vital Statistics, Vital events, Sources of data collection on Vital Statistics and errors they suffer from.
Week 5	Measurement of Population, Distinction between Rate and Ratio, Ratio of Vital events, Measures of Mortality: Crude Death Rate. Practical work.
Week 6	Specific Death Rate, Standardized Death Rate, Direct and Indirect Methods of Standardization, Practical work.
Week 7	Infant Mortality Rate, Relative Merits and Demerits of all the Rates. Practical work.
Week 8	Concepts of Stable and Stationary Populations, Central Mortality Rate, Force of Mortality. Approximate expressions for Force of Mortality.
Week 9	Introduction to Life Tables, Life Table Functions and Columns, Assumptions in the construction of Life Tables, Various relationships in the columns of a life table.
Week 10	Construction of Life Tables Uses of Life Tables, Concept of an Abridged Life Tables.Practical work.
Week 11	Life Table Functions and Columns of an Abridged Life Table, Types of Abridgement, Construction of an Abridged Life Table by Reed and Merrell method. Practical work.
Week 12	By Greville's method, and by King's method. Introduction to the concept of Fertility, Difference between Fertility and Fecundity. Practical work.
Week 13	Measures of Fertility: Crude Birth Rate, General Fertility Rate. Practical work.
Week 14	Specific Fertility Rate, Total Fertility Rate, Relative merits and demerits of all the Rates. Practical work.
Week 15	Measures of Population Growth: Crude Rate of Natural Increase, Pearl's Vital Index, Gross Reproduction Rate, Net Reproduction Rate, their relative merits and demerits. Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Distinction between Vital Statistics and Demography.	Class room lectures and discussions.	Participation in class discussion.
I	Errors in Demographic data.	Class room lectures and discussions.	Participation in class discussion.
I	To check the completeness of registration data using Chandrasekaran-Deming formula.	Class room lectures and discussions.	Participation in class discussion.
I	Use of Myer's and UN indices in evaluating age data.	Class room lectures and discussions.	Participation in class discussion.

I	Use of Balancing equations, Population Composition and Dependency Ratio	Class room lectures and discussions.	Participation in class discussion.
	Understanding of the basic concepts in Demographic analysis and to take care of errors in demographic data.	Class Test/Assignment Work.	Depth of understanding in theoretical concepts.
II	Sources of data collection on Vital Statistics and errors therein.	Class room lectures and discussions.	Participation in class discussion.
II	Measurement of Population, Distinction between Rate and Ratio.	Class room lectures and discussions.	Participation in class discussion.
II	Basic measures of Mortality.	(i) Class room lectures and discussions. (ii) Practical work based on different measures of mortality.	Participation in class discussion.
	Understanding the primary sources of data collection on Vital events and learning some of the important measures of mortality.	Class Test/Assignment work.	(i) Depth of understanding in theoretical concepts. (ii) Ability to choose appropriate measures of mortality in different situations with clear reasoning.
III	Concepts of Stable and Stationary Populations.	Class room lectures and discussions.	Participation in class discussion.
III	Concept of Life Tables, their construction and uses.	(i) Class room lectures and discussions. (ii) Practical work based on the construction of life tables.	Participation in class discussion.
IV	Concept of Abridged life tables and their construction by Reed-Merrell method, Greville's method and King's Method.	(i) Class room lectures and discussions. (ii) Practical work based on the construction of Abridged life tables.	Participation in class discussion.
	Learning the concepts of Complete and Abridged Life Tables and their construction.	Class Test/Assignment work.	Depth of understanding in theoretical concepts.
IV	Basic measures of Fertility. Measures of Population Growth.	(i) Class room lectures and discussions. (ii) Practical work based on different measures of fertility and population growth.	Participation in class discussion.

	Learning the basic measures of Fertility and Population growth.	Class Test/Assignment work.	(i) Depth of understanding in theoretical concepts. (ii) Ability to choose appropriate measures of fertility and population growth in different situations with clear reasoning.
	Application of the concepts learnt. (Optional)	Project Work/Presentation.	Ability to apply the concepts learnt in real life.

Keywords: Demography and Population Statistics, Vital Statistics, Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates, Stationary and Stable population Life Tables.

Bachelor of Science (Hons.) in Statistics
Semester V
STAT-DSE-2(A): Operations Research

Credits: 6 **Marks: 150**

Course Objectives:

The learning objectives include:

- To study various Operational Research Techniques and Models.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of Operational Research Techniques
- Linear Programming.
- Transportation and assignment problems
- Game Theory
- Inventory Models

Contents:

UNIT I

Introduction to Operations Research (O.R.): Definition and phases of O.R.Model building, various types of O.R. problems.

Linear Programming Problem (L.P.P.): Mathematical formulation of the L.P.P, graphical solutions of L.P.P. Simplex method for solving L.P.P. Charne's M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method. Economic interpretation of Duality. Post-optimality analysis.

UNIT II

Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem.

Assignment problem: Hungarian method to find optimal assignment, special cases of assignment problem.

UNIT III

Game theory: Rectangular game, minimax - maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy

Networking: Shortest route and minimal spanning tree problem.

UNIT IV

Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks.

SUGGESTED READINGS:

1. Taha, H. A. (2007). *Operations Research: An Introduction*, 8thEd., Prentice Hall of

India.

2. Swarup, K., Gupta, P.K. and Man Mohan (2007). *Operations Research*, 13th Ed., Sultan Chand and Sons.

PRACTICAL/ LAB WORK (Using TORA/WINQSB/LINGO)
List of Practicals:

1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique and Charne's Big M method involving artificial variables.
2. Identifying Special cases by Graphical and Simplex method and interpretation:
   a) Degenerate solution
   b) Unbounded solution
   c) Alternate solution
   d) Infeasible solution
3. Post-optimality:
   a) Addition of constraint
   b) Change in requirement vector
   c) Addition of new activity
   d) Change in cost vector
4. Allocation problem using Transportation model.
5. Allocation problem using Assignment model.
6. Networking problem:
   a) Minimal spanning tree problem
   b) Shortest route problem
7. Problems based on game matrix:
   a) Graphical solution to mx2 / 2xn rectangular game
   b) Mixed strategy
8. To find optimal inventory policy for EOQ models and its variations.
9. To solve all-units quantity discounts model.

Week-wise Teaching Plan

Week 1	Introduction to Operations Research, phases of O.R.
Week 2	Model building, various types of O.R. problems.
Week 3	Linear Programming Problem, Mathematical formulation of the L.P.P. Practical work.
Week 4-5	Graphical solutions of a L.P.P. Simplex method for solving L.P.P., Charne's M-technique for solving L.P.P. involving artificial variables. Practical work.
Week 6-8	Special cases of L.P.P. Concept of Duality in L.P.P., Dual simplex method. Post-optimality analysis. Practical work.
Week 9	Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem. Practical work.
Week 10	Assignment problem: Hungarian method to find optimal assignment, special cases of assignment problem. Practical work.
Week 11	Game theory: Rectangular game, minimax-maximin principle. Solution to rectangular game using graphical method, dominance and modified

	dominance property to reduce the game matrix and solution to rectangular game with mixed strategy. Practical work.
Week12	Networking: Shortest route and minimal spanning tree problem. Practical work.
Week 13	Inventory Management: ABC inventory system, characteristics of inventory system. Practical work.
Week 14-15	EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks. Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Introduction to Operations Research: Concepts and definition.	Class room lectures and discussions.	Participation in class discussion.
	Introduction to Linear Programming Problems. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method. Economic interpretation of Duality. Post-optimality analysis.	Class room lectures and discussions. Practical work.	Participation in class discussion.
A*	Understanding of LPP.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts
II	Transportation Problem.	Class room lectures and discussions. Practical work.	Participation in class discussion.
	Assignment Problem.	Class room lectures and discussions. Practical work.	Participation in class discussion.
III	Game Theory.	Class room lectures and discussions. Practical work.	Participation in class discussion.
	Networking.	Class room lectures and discussions. Practical work.	Participation in class discussion.
B*	Concepts of Transportation, assignment, game theory and Networking.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts
IV	Inventory Models.	Class room lectures and discussions. Practical work.	Participation in class discussion.

C*	Various inventory models.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keyword: Linear Programming Problem, Transportation Problem, Assignment Problem, Game theory, Networking, Various inventory models.

Bachelor of Science (Hons.) in Statistics
Semester V
STAT-DSE 2-(B): Econometrics

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include**:**
- A broad knowledge of regression analysis relevant for analysing economic data.
- Interpretation and critical evaluation of the outcomes of empirical analysis.
- Distinguish the results of violating the assumptions of classical regression model.
- To judge the validity of the economic theories and carry out their evaluation in numerical terms.
- To extract useful information about important economic policy issues from the available data.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- The fundamental concepts of econometrics.
- Specification of the model.
- Multiple Linear Regression.
- Multicollinearity.
- Heteroscedasticity.
- Autocorrelation.
- Autoregressive and Lag models.

Contents:

UNIT I
Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics. General linear model (GLM).Estimation under linear restrictions.

UNIT II
Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity.

UNIT III

Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

UNIT IV
Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions

of heteroscedasticity. Autoregressive and Lag models.

SUGGESTED READINGS:

1. Gujarati, D. and Guneshker, S. (2007). *Basic Econometrics*, 4th Ed., McGraw Hill Companies.
2. Johnston, J. (1972). *Econometric Methods*, 2nd Ed., McGraw Hill International.
3. Koutsoyiannis, A. (2004). *Theory of Econometrics*, 2 Ed., Palgrave Macmillan Limited.
4. Maddala, G.S. and Lahiri, K. (2009). *Introduction to Econometrics*, 4 Ed., John Wiley & Sons.

PRACTICAL /LAB WORK
List of Practicals:

1. Problems based on estimation of General linear model.
2. Testing of parameters of General linear model.
3. Forecasting of General linear model.
4. Problems related to consequences of Multicollinearity.
5. Diagnostics of Multicollinearity.
6. Problems related to consequences of Autocorrelation (AR(I)).
7. Diagnostics of Autocorrelation.
8. Estimation of General linear model under Autocorrelation.
9. Problems related to consequences Heteroscedasticity.
10. Diagnostics of Heteroscedasticity.
11. Estimation of problems of General linear model under Heteroscedastic disturbance terms.
12. Problems concerning specification errors as a reason for induction of Autocorrelation, Heteroscdasticity and Multicollinearity.
13. Problems related to General linear model under (Aitken Estimation).
14. Problems on Autoregressive and Lag models.

Week-wise Teaching Plan

Week 1	Introduction and Objective behind building Econometric Models.
Week 1-3	General linear models. Practical work.
Week 4	Estimation under linear restrictions, Practical work.
Week 5-7	Multicollinearity, Concepts, Consequences, Tests for detection and Remedies. Practical work.
Week 8-9	Generalized least squares, Concepts**,** Aitken's Estimator, Prediction**.** Practical work.
Week 10-11	Autocorrelation, Concepts, Consequences, Tests for detection and Remedies. Practical work.
Week 12-13	Heteroscedasticity, Concepts, Consequences, Tests for detection and Remedies. Practical work.
Week 14-15	Autoregressive and Lag models, Concepts, Consequences and Remedies.Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Introduction, fundamental concept of econometrics and objectives behind building econometric models.	Class room lectures and discussions dependent variable depends on two or more explanatory.	(i) Participation in class discussion. (ii) Identification of models.
I.	Specification of models in which the variables. Estimation of unkown parameters, their properties, adjusted and unadjused R^2	Class room lectures and discussions. Practical work based on multiple regression models.	(i) Participation in class discussion. (ii) Estimation, formulation of null hypotheses, interpretation of the estimated regression model and conclusion.
I	Estimation under linear restrictions.	Class room lectures and discussions. Practical work based on multiple regression models with addition linear restrictions on parameters.	(i) Participation in class discussion. (ii) Estimation, formulation of null hypotheses, interpretation of the estimated regression model and conclusion in case of multiple regression models with additional linear restrictions
II	Multicollinearity Concept Consequences Tests for detection of multicollinearity Remedies.	Class room lectures and discussions. Practical Work based on multiple regression models involving multicollinearity, its consequences and diagnostics	(i) Participation in class discussion. (ii) Estimation, formulation of null hypotheses, interpretation of the estimated regression model and conclusion in case of models with multicollinearity. (iii)Diagnosis of multicollinearity.
A*	Understanding of basic concept of econometrics, estimation of parameters of regression models and their significance tests, estimation under linear restriction, multicollinearity.	Class test / Assignment work.	Extent of clarity in theoretical concepts.
III	Generalized least squares estimation Concept	Class room lectures and discussions. Practical	(i) Participation in class discussion.

	Aitken's Estimators Preciction in case of GLSE.	work prediction in case of GLSE.	(ii) Estimation, prediction formulation of null hypotheses, interpretation of the estimated regression model and conclusion in case of GLSE.
III	Auto correlation/ Serial correlation Concept Consequences Tests for detection of Autocorrelation Remedies.	Classroom lectures and discussions. Practical work based on autocorrelated models.	(i) Participation in class discussion. (ii) Diagnosis, formulation of null hypotheses, interpretation of the estimated regression model and conclusion in case of autocorrelated models. (iii) Estimation with correction for autocorrelation.
IV	Heteroscedasticity Concept Consequences Tests for detection of Hetroscedasticity Remedies.	Classroom lectures and discussions Practical work based on heteroscedastic models.	(i) Participation in class discussion. (ii) Comparison of OLSE with or without hetroscedasticity and GLSE in case of hetroscedasticity. (iii) Diagnosis, formulation of null hypotheses, interpretation of the estimated regression model and conclusion in case of heteroscedastic models.
	Autoregressive and Lag models Concepts Consequences Remedies.	Classroom lectures and discussions Practical work based on Lag models.	(i) Participation in class discussion. (ii) Estimation in case of distributed lag models using Koyck's transformation.
B*	Understanding the concepts of GLSE, Autocorrelation, Hetroscedasticity and Lag Models.	Assignment work/ class test.	Extent of clarity in theoretical concepts.

*As per requirements of Internal Assessment for B.Sc.(Hons).

Keywords: Econometric models, General linear model, Generalized least squares estimation, Autocorrelation, Hetroscedasticity and Lag Models.

Bachelor of Science (Hons.) in Statistics

Semester VI
STAT-DSE-3(A): Actuarial Statistics

Credits: 6 **Marks: 150**

Course Objectives:
To learn advanced techniques in Actuarial Science with practical applications in daily life.

Course Learning Outcomes:
Tools for applying actuarial methods in phenomena for financial research and insurance. This includes computation of premiums and settlement of claims.

Contents:

UNIT I

Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables. Utility theory: Utility functions, expected utility criterion, types of utility function, insurance and utility theory.

UNIT II

Principles of Premium Calculation: Properties of premium principles, examples of premium principles. Individual risk models: models for individual claims, the sum of independent claims, approximations and their applications.

UNIT III

Survival Distribution and Life Tables: Uncertainty of age at death, survival function, time until-death for a person, curate future lifetime, force of mortality, life tables with examples, deterministic survivorship group, life table characteristics, assumptions for fractional age, some analytical laws of mortality.

UNIT IV

Life Insurance: Models for insurance payable at the moment of death, insurance payable at the end of the year of death and their relationships. Life annuities: continuous life annuities, discrete life annuities, life annuities with periodic payments. Premiums: continuous and discrete premiums.

SUGGESTED READINGS:

1. Atkinson, M.E. and Dickson, D.C.M. (2011). *An Introduction to Actuarial Studies*, Elgar Publishing.

2. Dickson, C. M. D. (2005). *Insurance Risk and Ruin (International Series no.1 Actuarial Science),* Cambridge University Press. Bowers, N. L., Gerber, H. U., Hickman.
3. Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). *Actuarial Mathematics, Society of Actuaries*, Itasca, Illinois, U.S.A.

PRACTICAL / LAB WORK
List of Practicals:

1. Risk computation for different utility models.
2. Discrete and continuous risk calculations.
3. Calculation of aggregate claims for collective risks.
4. Calculation of aggregate claim for individual risks.
5. Computing Ruin probabilities and aggregate losses.
6. Annuity and present value of contract.
7. Computing premium for different insurance schemes.
8. Practical based on life models and tables.

Week-wise Teaching Plan

Week 1	Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables.
Week 2- 3	Utility theory: Utility functions, expected utility criterion, types of utility function, insurance and utility theory.
Weeks 4 - 5	Principles of Premium Calculation: Properties of premium principles, examples of premium principles.
Weeks 6 - 7	Individual risk models: models for individual claims, the sum of independent claims, approximations and their applications.
Weeks 8 - 9	Survival Distribution and Life Tables: Uncertainty of age at death, survival function, timeuntil-death for a person, curate future lifetime, force of mortality, life tables with examples, deterministic survivorship group, life table characteristics, assumptions for fractional age, some analytical laws of mortality.
Weeks 10 - 11	Life Insurance: Models for insurance payable at the moment of death, insurance payable at the end of the year of death and their relationships.
Weeks 12- 13	Life annuities: continuous life annuities, discrete life annuities, life annuities with periodic payments.
Week14	Premiums: continuous and discrete premiums.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Introduction to Insurance	Reinsurance, Utility Functions.	Computing moments of mixed random variables and applying

	Applications.		Expected Utility Criterion.
2.	Principles of Premium Calculation and Individual risk models.	Examples of premium principles. Models for individual claims.	Premium Calculation based on principles. Properties of premium principles. Computing the sum of independent claims, approximations and their applications.
3.	Survival Distribution and Life Tables.	Uncertainty of age at death, survival function, time until-death for a person, curate future lifetime, force of mortality, life tables with examples.	Deterministic survivorship group, life table characteristics, assumptions for fractional age, some analytical laws of mortality. Differentiate between Select and Ultimate Life Tables.
4.	Life Insurance.	Models for insurance Life annuities Computation of premiums.	Learning functions based on Insurance payable at the moment of death, insurance payable at the end of the year of death and their relationships. Continuous life annuities, discrete life annuities and the respective premium calculations.

Keywords: Insurance, Utility functions, Premiums, Life Tables, Survival functions, Annuities.

Bachelor of Science (Hons.) in Statistics
Semester VI
STAT-DSE-3(B): Biostatistics and Survival Analysis

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include:
- To analyse censored data and its application in public health.
- Estimate death probabilities by using the theory of competing risks in a cause-specific mortality study.
- Need of conducting clinical trials for introducing new drug.
- To compute probability of gametes in different generations under random mating.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- The fundamental concepts of survival functions and their interrelationship.
- Survival distributions and their applications.
- Handling censored data and estimating mean survival time.
- Actuarial and Kaplan-Meier methods (Non- parametric methods).
- Competing Risk Theory. Dependent and independent risk.
- Simple Stochastic epidemic model.
- Basic concept of genetics.
- Need of Clinical drug trials.

Contents:

UNIT I

Survival Analysis: Functions of survival times, survival distributions and their applications- exponential, gamma, Weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shaped hazard function.Censoring Schemes: Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for Type I and Type II censored data with numerical examples. Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.

UNIT II

Competing Risk Theory: Indices for measurement of probability of death under competing risks and their inter-relations.Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods.Theory of independent and dependent risks. Bivariate normal dependent risk model.

UNIT III

Stochastic Epidemic Models: Simple epidemic models, general epidemic model definition and concept (without derivation). Duration of an epidemic.

UNIT IV

Statistical Genetics: Introduction, concepts-Genotype, Phenotype, Dominance, Recessiveness, Linkage and Recombination, Coupling and Repulsion. Mendelian laws of Heredity, Random mating, Gametic Array relation between genotypic array and gametic array under random mating. Distribution of genotypes under random mating. Clinical Trials: Planning and design of clinical trials, Phase I, II and III trials. Blinding: Single, Double, Triple.

SUGGESTED READINGS:

1. Biswas, S. (2007). *Applied Stochastic Processes*: *A Biostatistical and Population Oriented Approach*, Reprinted 2nd Ed., New Central Book Agency.
2. Elandt-Johnson R.C (1971). *Probability model and Statistical Methods in Genetics*, John Wiley & Sons.
3. Indrayan, A. (2008). *Medical Biostatistics*, 2nd Ed., Chapman and Hall/CRC.
4. Lee, E.T. and Wang, J.W. (2003). *Statistical Methods for Survival data Analysis*, 3rd Ed., John Wiley & Sons.
5. Narayan P. (1999). *Statistical Genetics*, New Age International Pvt. Ltd.
6. Miller, R. G. (2011). *Survival Analysis*. John Wiley & Sons.

PRACTICAL/LAB WORK
List of Practicals:

1. Estimation of survival function.
2. Determination of death density function and hazard function.
3. Identification of type of censoring and to estimate survival time for type I censored data.
4. Identification of type of censoring and to estimate survival time for type II censored data.
5. Identification of type of censoring and to estimate survival time for progressively type I censored data.
6. Estimation of mean survival time and variance of the estimator for type I censored data.
7. Estimation of mean survival time and variance of the estimator for type II censored data.
8. Estimation of mean survival time and variance of the estimator for progressively type I censored data.
9. To estimate the survival function and variance of the estimator using Non-parametric methods with Actuarial methods
10. To estimate the survival function and variance of the estimator using Non-parametric method with Kaplan-Meier method.
11. To estimate Crude probability of death.

12. To estimate Net-type I probability of death.
13. To estimate Net-type II probability of death.
14. To estimate partially crude probability of death.
15. To estimate gene frequencies F.

Week-wise Teaching Plan

Week 1-2	Survival Analysis: To study various survival functions and interrelationship between them. Introduction to various survival models.
Week 3-4	Censoring Schemes: Definition of censoring. Study of Type I, Type II and progressive or random censoring with biological examples.
Week 5-6	Non parametric Methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.
Week 7-8	Competing Risk Theory: Introduction of various measures of competing risk theory. Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods.
Week 9	Theory of independent and dependent risks: Bivariate normal dependent risk model.
Week 10-11	Stochastic Epidemic Models: Definition of epidemic, susceptibles and infective. Simple and general epidemic model. Duration of an epidemic.
Week 12-13	Statistical Genetics: Introduction, concepts-Genotype, Phenotype, Dominance, Recessiveness, Linkage and Recombination, Coupling and Repulsion. Mendelian laws of Heredity, Random mating, Gametic array, relation between genotypic array and gametic array under random mating. Segregation matrix. Estimating probabilities of gametes for future generations.
Week 14	Clinical trials: Phases of clinical drug trial. Blinding.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Basic concepts of survival functions.	Class room lectures and discussions.	Participation in class discussion.
I	Survival distributions and their applications.Bath tub model.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
I	Censored data: Type I, Type II and progressive or random censoring with biological examples.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
I	Estimation of survival time under censoring schemes.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
I	Actuarial and Kaplan-Meier methods for estimating survival function and	(i) Class room lectures and	Participation in class discussion.

	variance of the Estimator.	discussions. (ii) Practical work.	
II	Measurement of probability of death under competing risks.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
II	Inter-relationship between different measures of probability of death.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
II	Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
II	Independent and dependent risks.	(i) Class room lectures and discussions.	Participation in class discussion.
			Class test/assignment on first two units.
III	Epidemic models. General epidemic model definition. Simple epidemic models & duration of an epidemic	(i) Class room lectures and discussions.	Participation in class discussion.
IV	Statistical Genetics.	(i) Class room lectures and discussions. (ii) Practical work	Participation in class discussion.
IV	Clinical Drug Trials.	(i) Class room lectures and discussions.	Participation in class discussion.
IV	Blinding.	(i) Class room lectures and discussions.	Participation in class discussion.
			Class test/assignment on last two units.

Keywords: Censored data, Actuarial and Kaplan-Meier methods, Survival function, Epidemic models, Clinical Drug Trials.

Bachelor of Science (Hons.) in Statistics
Semester VI
STAT-DSE-4(A): Financial Statistics

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include:
- To understand financial markets and in particular, derivative markets.
- To develop an understanding of stochastic calculus.
- To apply the techniques of stochastic calculus to price the products of derivative markets.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- The fundamental concepts of investments and products of financial markets.
- Derivative markets.
- Continuous time stochastic processes.
- Brownian motion and Wiener process.
- Stochastic calculus and Itô Calculus.
- Stochastic differential equations.
- Black Scholes' model.
- Hedging of financial portfolios.

Contents:

UNIT I

Introduction to investment and markets: Cash flows- deterministic and random, Basic theory of interest, bonds and yields, Term structure of interest rates, Portfolio Theory.

UNIT II

Introduction to derivatives, Tools Needed for Option Pricing: Forward contracts, spot price, forward price, future price, Call and put options, Zero-coupon bonds and discount bonds, Pricing derivatives: Arbitrage relations and perfect financial markets, Pricing futures, Put-call parity for European and American options, Relationship between strike price and option price. Discrete Stochastic Processes, Binomial processes, General random walks, Geometric random walks, Binomial models, Trinomial models.

UNIT III

Continuous time processes – Brownian motion, Geometric Brownian motion, Wiener process; Introduction to stochastic calculus: stochastic integration, stochastic differential equations and their solutions; Itô's lemma.

UNIT IV

Intrinsic of option markets: Black-Scholes differential equation, Black-Scholes formula for European and American options, Implied volatility, Binomial Model for European options:

Cox-Ross-Rubinstein approach to option pricing. Discrete dividends, Trinomial model for American options, Hedging portfolios: Delta, Gamma and Theta hedging.

SUGGESTED READINGS:

1. David, G. L. (2015). *Investment Science*, Oxford University Press(South Asian edition)
2. Franke, J., Hardle, W.K. and Hafner, C.M. (2011). *Statistics of Financial Markets: An Introduction*, 3rd Ed., Springer Publications.
3. Stanley, L. S. (2012). *A Course on Statistics for Finance*, Chapman and Hall/CRC.

PRACTICAL / LAB WORK
List of Practicals:

Mode of Conducting Practical Examination: The students should be encouraged to perform practical problems on computers using whatsoever software/package as far as possible.

1. To compute NPV and to obtain IRR of the investments.
2. To verify “no arbitrage” principle.
3. To price future / forward contracts.
4. To construct binomial trees and to evaluate options using these trees.
5. Simulation of continuous time stochastic processes.
6. To price options using Black – Scholes formula.
7. Pricing of options using discrete time models.
8. Impact of dividend on option prices.
9. Call-put parity for options.
10. Application of Greeks to hedge investment portfolios.

Week-wise Teaching Plan

Week 1-3	Introduction to investment and markets: Cash flows- deterministic and random, basic theory of interest, bonds and yields, term structure of interest rates, portfolio theory.
Week 4-7	Introduction to derivatives, Tools Needed For Option Pricing: Forward contracts, spot price, forward price, future price. Call and put options, zero-coupon bonds and discount bonds, Pricing derivatives: Arbitrage relations and perfect financial markets, pricing futures, put-call parity for European and American options, relationship between strike price and option price.
Week 8	Discrete Stochastic Processes, Binomial processes, General random walks, Geometric random walks, Binomial models, Trinomial models.
Week 9-10	Continuous time processes - Brownian motion, geometric Brownian motion, Wiener process; Introduction to stochastic calculus.
Week 11-12	Stochastic differential equations and their solutions; Itô’s lemma.
Week 13-15	Intrinsic of option markets: Black-Scholes differential equation, Black-Scholes formula for European and American options, Implied volatility, Binomial Model for European options: Cox-Ross-Rubinstein approach to option pricing. Discrete dividends, Trinomial model for American options, Hedging portfolios: Delta, Gamma and Theta hedging.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	The fundamental concepts of investments.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
II	Products of financial markets.	Class room lectures and discussions.	Participation in class discussion.
II	Derivative markets.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
III	Continuous time stochastic processes.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
III	Brownian motion and Wiener process.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
III	Stochastic calculus and Itô Calculus.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
			Class test/assignment on first two units
III	Stochastic differential equations.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
IV	Black Scholes’ model	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
IV	Hedging of financial portfolios.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
			Class test/assignment on last two units

Keywords: Financial Markets, Assets, Rate of Interest,Returns, Derivatives, Forwards, Futures, Options, Risk and Risk Management, Stochastic Calculus, Wiener process, Ito lemma, Pricing derivatives, Black-Scholes' option pricing formula, CRR model, Binomial Model, Hedging.

Bachelor of Science (Hons.) in Statistics
Semester VI
STAT-DSE-4(B): Project Work

Credits: 6

Course Objectives:

The aim of the course is to initiate students to write and present a statistical report, under the supervision of a faculty, on some area of human interest. The project work will provide hands on training to the students to deal with data emanating from some real life situation and propel them to dwell on some theory or relate it to some theoretical concepts.

Course Learning Outcomes:
The project work will provide hands on training to the students to deal with data and relate it to some theoretical concepts.

Contents:

UNIT I

Define the scope and objectives of the research project. Objectives of project, project work approaches, significance of project work, defining the project work, necessity of defining the project work, technique Involved, Census and Sample Survey, implications of a sample design, steps in sampling design, criteria of selecting a sampling procedure, Measurement and Scaling Techniques Measurement Scales, sources of error in measurement, Tests of sound measurement, scaling, scale classification, scale construction Techniques.

UNIT II

Project Schedule Methods of data collection, Collection of Primary Data, observation method, interview method, collection of data through questionnaires, collection of data through schedules, difference between questionnaires and schedules, some other methods of data collection, collection of secondary data, selection of appropriate method for data collection.

UNIT III

Processing operations, some problems in processing, elements/types of analysis, need for sampling, important sampling distributions, estimation, sample size and its determination, determination of sample size through the approach based on precision rate and confidence level, determination of samples size through the approach based on Bayesian Statistics, testing of Hypotheses, basic concepts concerning testing of Hypotheses, procedure for Hypothesis testing, flow diagram for Hypothesis testing, measuring the power of a Hypothesis test, tests of Hypotheses, parametric and non-parametric, limitations of the tests of Hypotheses, Analysis of Variance (ANOVA), the basic principle of ANOVA, ANOVA technique, Analysis of Co-variance (ANOCOVA), assumptions in ANOCOVA, Multivariate Techniques, methods of Factor Analysis, rotation in Factor Analysis, Processing and Analysis of Data.

UNIT IV

Meaning of Interpretation,Technique of Interpretation, precaution in Interpretation, significance of report project writing, different steps in writing project report, layout of the project report, types of reports, oral presentation, Mechanics of writing a research report, precautions for Writing project reports, conclusions. Interpretation and Report Writing.

SUGGESTED READINGS:

1. Cochran, W.G. and Cox, G.M. (1959): *Experimental Design*. Asia Publishing House.
2. Kothari, C.R. (2015): *Research Methodology: Methods and Techniques*, 3rd Edition reprint, New Age International Publishers.
3. Kumar, R (2011): *Research Methodology: A Step - by - Step Guide for Beginners*, SAGE publications.
4. Cochran, W.G. (2011): *Sampling Techniques* (3rd Ed.), Wiley Eastern John Wiley and Sons.
5. Murthy M.N. (1977): *Sampling Theory & Statistical Methods*, Statistical Pub. Society, Calcutta.
6. Sukhatme, P. V., Sukhatme, B. V., Sukhatme, S. and Asok, C. (1984): *Sampling Theories of Survey with Application,* IOWA State University Press and Indian Society of Agricultural Statistics.
7. Gujarati, D. and Sangeetha, S. (2007): *Basic Econometrics*, 4 Edition, McGraw Hill Companies.

Additional Resources:

1. Journal of Statistical Theory and Practice.
2. Communication in Statistics- Theory and Methods.
3. Journal of Statistical Theory and Applications.
4. Journal of Medical Statistics.

PRACTICAL / LAB WORK

The project work itself a practical problem and it relates to some theoretical concepts.

Week-wise Teaching Plan:

1. Validity of the project and how it can be used for benefit to the society.
2. To study step by step project work.

Facilitating the Achievement of Course Learning Outcomes:

As per their understanding and project work done by students.

Keywords: Project

Skill Enhancement Courses

Bachelor of Science (Hons.) in Statistics
STAT- SEC-1: Data Analysis Using Software Packages (SPSS)

Credits: 4 **Marks: 100**

Course Objectives:
The learning objectives include:
- To understand SPSS and its roles in problem solving.
- To understand data handling and its analysis.
- Learning the basic statistical software will help students to easily switch over to any other statistical software in future.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of SPSS.

Contents:

UNIT I

SPSS Basics, plot a graph viz. histograms (equal class intervals and unequal class intervals), box plot, bar graphs, line graphs, stem-leaf, frequency polygon, pie chart, ogives with graphical summaries of data.

UNIT II

Generate automated reports giving detailed descriptive statistics, correlation and lines of regression.

UNIT III

Random number generation using different probability distributions and sampling procedures. Fitting of polynomials and exponential curves. Problems based on fitting of suitable distribution. Normal probability plot.

UNIT IV

Simple analysis, create and manage statistical analysis projects, import data, Basics of statistical inference in order to understand hypothesis testing and compute p-values and confidence intervals. Comparison of several means. Syntax code editing.

SUGGESTED READINGS:

1. Knapp, H. (2014). *Introductory Statistics Using SPSS*, SAGE Publications India Private Ltd.
2. Cunningham, J.B. and Aldrich, J.O. (2014): *Using SPSS- An Interactive Hands-On Approach,* SAGE Publications India Private Ltd.

PRACTICAL/LAB WORK
List of Practicals:

1. Draw histogram for equal/unequal width class interval, Stem and Leaf plot,Box plot frequency polygon, pie chart, bar graphs, line charts, Ogive.
2. Construct frequency table using recode (having equal and unequal interval) and visual binning.
3. Compute descriptive statistics for raw data and grouped data and interpret by computing coefficient of variation, skewness and kurtosis.
4. Use of count, compute, compute with if and rank feature.
5. Calculate correlation coefficient (Karl Pearson), Spearman's rank correlation coefficient, Multiple and Partial correlation coefficient and fitting of two lines of regression and their plot.
6. Generation of random sample from Binomial, Poisson, Negative binomial, Uniform, Exponential, Normal, Gamma chi-square t and F distributions Stem and Leaf plots and Box Plots for these random Samples.
7. CLT for binomial and Poisson distribution. (Generate samples, compute their means and draw histogram along with normal curve; normal probability plot)
8. Compute cdf $F(x) = P(X \leq x)$ for random sample of observations drawn from theoretical distributions.
9. Draw simple random sample with/without replacement, stratified and systematic sample from a given data set and compute various measures by select cases and (or) complex sampling.
10. Fit linear, quadratic and exponential curve and find which one is best suited from the graph.
11. Obtain sampling distribution of sample mean in sampling from various distributions (sampling distribution can be shown to be normal by normal probability plot) as well as using recoding option and then computing quantiles.
12. Construct bivariate distribution using recode.
13. t-test for single mean, difference of means and Paired t-test, F-Test, Chi Square test for independence of attributes for raw data (using crosstab feature) and Chi Square test for independence of attributes (given contingency table), chi square test for goodness of fit and comparison of several means (ANOVA).
14. Generate a random sample and fit Binomial, Poisson and Negative Binomial distribution.
15. Comparison of series when (a) with missing observation (b) when missing observation is replaced by a constant (c) when missing observation is replaced by an average (mean, median or mode).
16. How to edit syntax, save it and retrieve it for subsequent analyses with the help of relevant example and Data import from other packages and export to other packages.

NOTE:

1. Students may be encouraged to complete at least one project (given some large data, students can analyze and prepare a report).
2. There will be no separate end semester theory examination in this paper and the evaluation will be done only through end semester practical examination, besides the internal assessment of 25 marks.

Week-wise Teaching Plan

Week 1	Introduction to SPSS: how to enter variable names and data. Generate a table of statistics and graph summarizing those statistics. Navigate the Variable View and Data View screens. Investigations of main menu and data editor tool bar. Save and open data and output files. To distinguish between variables measured at the nominal, ordinal and scale levels of measurements. To enter variables and their attributes.
Week 2	Use of count, compute, compute with if and rank feature.
Week 2-3	Concept of recode and visual binning, generation of frequency tables, To calculate measures of central tendency and measure of dispersion.
Week 4	To create basic graphs using Legacy Dialogs and Chart Builder methods, to edit basic graphs.
Week 5	Computation and interpretation of correlation coefficient (Pearson's and Spearman's). Test of significance for Pearson's correlation coefficient. Multiple and Partial correlation coefficients.
Week 6	Fitting of polynomial and exponential curves using built in functions. Fitting of most suitable curve.
Week 7	Fitting and plotting of regression lines.
Week 8	Generation of random sample from different distribution and their graphic representation.
Week 9	Calculations of CDF, to show CLT for different distributions. To plot the Normal Probability plot.
Week 10	Importing and Exporting files. How to deal with missing observations.
Week 11-12	Basics of Statistical inference for hypothesis testing, compute p-values and confidence interval. Testing of hypotheses-one sample t-test, paired sample t-test, Independent sample t-test, Test for comparison of several means. Chi Square test for Goodness of Fit.
Week 13	Constructing bivariate table and Chi Square test of Independence of attributes.
Week 14-15	How to select a SRS, systematic and stratified sample from a given population.
Week 15	Code editing using syntax file.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Introduction to SPSS.	Class room lectures and Practical work.	Participation in class discussion and completion of assignment.
I	Exposure to the descriptive statistics and different types of graphs.	Class room lectures and Practical work.	Participation in class discussion and completion of assignment.
II	Generation of reports with detailed descriptive statistics.	Class room lectures and Practical work.	Participation in class discussion and completion of assignment. Formulation of null hypotheses analyse and interpret the results.
II	Understanding of the concept of different		

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
	correlation coefficients.		
II	Concept of lines of Regression.		
III	Sampling procedures	Class room lectures and Practical work.	Participation in class discussion and completion of assignment.
III	Fitting of curves		
III	Generation of random numbers using different probability distributions.		
IV	Understanding of Hypothesis Testing.	Project Work and its presentation.	Identification of appropriate Test of Hypothesis, formulation of null hypothesis. Ability to analyse the data, interpret the result and draw conclusion.

Keywords: SPSS Basics**,** Box plot, Bar graphs, line graphs, Stem-leaf, Fitting of polynomial, Statistical inference, Code editing using syntax file.

Bachelor of Science (Hons.) in Statistics

STAT-SEC-1: Data Analysis Using Software Packages (MATLAB)

Credits: 4 **Marks: 100**

Course Objectives:

The objective of this course is to introduce MATLAB, MATLAB programming and statistics toolbox.

Course Learning Outcomes:

After completing this course, students will possess skills concerning

- Basic programming in MATLAB.
- Ability to solve statistical problems, numerical methods.
- Basic symbolic computations.

Contents:

UNIT I

Introduction –Desktop environment; help system. Data in MATLAB – Data objects in base MATLAB (scalars, characters, Arrays, strings, Cell-arrays, Structures, excluding Tables); Variables; Assignment statements; System variables; Accessing data elements; Example of Joining data sets. Data Import and Export – Text files, Comma-Separated Values files, Spreadsheet files. Miscellaneous Topics – workspace, dir, cd, copyfile, delete, what, who, whos, which, clear, close, clc and path commands; punctuation. Arithmetic operators; Functions in MATLAB – introduction, syntax for definition and use.
Visualizing Data: Basics – graph2d, graph3d; plot function – 2D, 3D, Scatter Plots; simple plot editing. Plots in 2D – Adding title, Labels, Legends; fplot; logarithmic plots; plotyy; axis and axes commands; subplot function; ginput; Discrete plots using stem, stair; Statistical plots.

UNIT II

Descriptive Statistics- Measures of Location – Mean, Median, Mode. Measures of Dispersion – Range, Variance, Standard Deviation; Covariance (cov) and Correlation (corrcoef). Quantiles, Interquartile range, Skewness. Visualizing the Data distribution through Histogram (hist and histfit), normal probability plot (normplot) and Boxplot.

UNIT III

Probability distributions- Random number generation in Base MATLAB using rand and. Applications.

UNIT IV

Using statistics toolbox regarding computations relating to theoretical distributions: "…pdf", "…cdf", "…inv", "…stat", "…fit", "…rnd" for Continuous distributions (beta, Chi-square, exponential, gamma, Lognormal, Normal, Uniform); for Discrete distributions (binomial, Geometric, Poisson, Uniform).

Hypothesis Testing-Basic concepts – Right-tail, Left-tail, Two-tail region; Type-I & Type-II error, p-value; Confidence Intervals. Example of the z-Test. Elementary Symbolic Computations. ODE.

SUGGESTED READINGS:

1. D. Ray and S. Dey (2018): *A text book on MATLAB Programming for Engineering and Science*, 2nd ed. Shroff Publishers and Distributors, Pvt. Ltd., Navi Mumbai.
2. M.J. Cho and W. L. Martinez (2014). *Statistics in MATLAB: A Primer,* Chapman & Hall/CRC
3. Singh, Y. K. and Chaudhuri, B. B. (2007). *MATLAB Programming,* PHI, New Delhi

PRACTICAL/LAB WORK
List of Practicals

1. To solve various problems of Matrix Theory, Algebra, Calculus
2. To solve differential equations
3. To calculate some descriptive statistics
4. To plot scatter diagram
5. To obtain the plot of given equation
6. To plot normal distribution and its derivatives, truncated normal distribution
7. To plot contour of bivariate normal distribution
8. To generate random sample from various continuous& discrete distributions
9. To investigate the shape of gamma distribution
10. To investigate the shape of 3-D surface
11. To develop a function for computation of e^x
12. To develop a function for measures of location
13. To develop a function for measures of dispersion
14. To generate random walk for N steps and plot them

NOTE:

There will be no separate end semester theory examination in this paper and the evaluation will be done only through end semester practical examination, besides the internal assessment of 25 marks.

Week-wise Teaching Plan:

Week 1-3	Introduction. Data objects in base MATLAB.
Week 3-4	Variables; Assignment statements; System variables; Accessing data elements; Example of Joining data sets.
Week 5	Data Import and Export – Text files, Comma-Separated Values files, Spreadsheet files.
Week 6	Workspace, dir, cd, copyfile, delete, what, who, whos, which, clear, close, clc and path commands; punctuation. Arithmetic operators.
Week 7	Functions in MATLAB – introduction, syntax for definition and use.
Week 8	Visualizing Data.
Week 9-10	Descriptive Statistics- Measures of Location & Dispersion. Quantiles, Interquartile range, Skewness. Visualizing the Data distribution through

	Histogram (hist and histfit), normal probability plot and Boxplot.
Week 10-11	Random number generation in Base MATLAB using rand, randn. Applications.
Week 11-13	Using statistics toolbox. Hypothesis Testing
Week 13-14	Elementary Symbolic Computations. ODE

Facilitating the achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Introduction. Data objects in base MATLAB. Variables; Assignment statements; syntax	(i) Class room lectures and discussions. (ii) Practical work	(i) Participation in class discussion. (ii) Based on problem solving in Lab.
	Data Import and Export		
	Common system commands; Functions in MATLAB		
	Visualizing Data		
II	Descriptive Statistics. Quantiles, Interquartile range, Skewness.	(i) Class room lectures and discussions. (ii) Practical work.	(i) Participation in class discussion (ii) Based on problem solving in Lab.
	Histogram (hist and histfit), normal probability plot (normplot) and Boxplot		
A*	Appraisal-First	Class Test/ Assignment work	Extent of clarity in theoretical& practical concepts
III	Random number generation in Base MATLAB using rand, randn. Applications	(i) Class room lectures and discussions. (ii) Practical work based.	(i) Participation in class discussion. (ii) Based on problem solving in Lab. (iii) Ability to solve application problem
IV	Toolboxes in MATLAB, Using statistics toolbox		
	Hypothesis Testing; Confidence Intervals		
	Elementary Symbolic Computations. ODE.		
B*	Appraisal-Second	Class Test/ Assignment work	Extent of clarity in theoretical& practical concepts.

*As per requirements of Internal Assessment for B.Sc. (Honrs).

Keywords: Data objects in base MATLAB, Variables, Assignment statements, Syntax, Functions in MATLAB, Random number generation, Hypothesis Testing, Toolboxes in MATLAB.

Bachelor of Science (Hons.) in Statistics

STAT-SEC-2: Statistical Data Analysis Using R

Credits: 4 **Marks: 100**

Course Objectives:
The learning objectives include:
- Review and expand upon core topics in probability and statistics.
- Practice of graphical interpretation, probability distribution and data analysis using `R'.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- Various Graphical representation and interpretation of data.
- Automated reports giving detailed descriptive statistics.
- Understanding data and fitting suitable distribution.
- Testing of hypothesis, p-value and confidence interval.
- Random number generation and sampling procedures.
- Importing data, Code editing in R and flow controls if (), for (), while ().

Contents:

UNIT I

Learn how to load data, plot a graph: bar-plot, pie-chart, and box plot, stem-leaf, histograms (equal class intervals and unequal class intervals), frequency polygon, ogives with graphical summaries of data.

UNIT II

Generate automated reports giving detailed descriptive statistics, scatter plot; correlation and lines of regression, curvilinear regression.

UNIT III

Introduction to flow control: if (), for () and while () loop; Random number generation and sampling procedures. Application problems based on fitting of suitable distribution, Q-Q plot, Multiple Regression.

UNIT IV

Basics of statistical inference in order to understand hypothesis testing, compute p-values and confidence intervals. Simple analysis and create and manage statistical analysis projects, import data, code editing.

SUGGESTED READINGS:

1. Braun, W. J., and Murdoch, D. J. (2007). *A First Course in Statistical Programming with R*. Cambridge University Press. New York.
2. Crawley, M. J. (2012). *The R Book*. 2nd Ed., John Wiley & Sons.
3. Dalgaard, P. (2008). *Introductory Statistics with R*. 2nd Ed., Springer.
4. Gardener, M. (2012). *Beginning R: The Statistical Programming Language*, Wiley Publications.

Week-wise Teaching Plan

Week 1	Introduction to R, Installation of packages and modules, loading of data, playing with arithmetic expressions. Introduction to data types.
Week 2-4	Graphical representation and interpretation viz. bar-plot, pie-chart, and box plot, stem-leaf, histograms (equal class intervals and unequal class intervals), frequency polygon, ogives with graphical summaries of data. Practical work.
Week 5	Generate automated reports giving detailed descriptive statistics. Practical work.
Week 6-7	Import data, code editing, Scatter plot; correlation and lines of regression, Curvilinear regression. Practical work.
Week 8-9	User defined functions, Introduction to flow control: if(), for() and while() loop. Practical work.
Week 10	Random number generation and sampling procedures. Application problems based on fitting of suitable distribution. Practical work.
Week 11	Q-Q plot, Multiple Regression. Practical work.
Week 12-13	Basics of statistical inference in order to understand hypothesis testing, compute p-values and confidence intervals. Practical work.
Week 14-15	Simple analysis and create and manage statistical analysis projects.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Graphical representation and interpretation of data.	(i) Class room lectures and discussions. (ii) Practical work based on data representation in the form of frequency distribution.	Participation in class discussion. Identification of form of data and representation of central tendency, dispersion and outliers in the data.
A*	Understanding data and graphical representation.	Class Test/ Assignment work.	Extent of clarity of theoretical concepts studied in core papers with respect to graphical representation of data.
II	Descriptive Statistics	(i) Class room	(i) Participation in class

	and summaries of data.	lectures and discussions. (ii) Practical work based on the probability distributions and inferential Statistics.	discussion. (ii) Identification of probability distribution, formulation of null hypothesis, appropriate analysis, interpretation of results and conclusion. Extent of clarity in theoretical concepts studied in core topics in probability and statistics.
III	Flow controls if, for, while.		
III	Understanding data and fitting suitable distribution.		
III	Random number generation and sampling procedures.		
IV	Importing data, Code editing in R.		
IV	Testing of hypothesis, p-value and confidence interval.		
B*	Understanding coding, hypothesis testing, sampling procedures and probability distributions.	Class Test/ Assignment work.	Extent of clarity of theoretical concepts studied in core papers with respect to data analysis.
C*	Simple analysis and create and manage statistical analysis projects.	Project Work and its presentation.	Ability to understand and draw inferential conclusion using data.

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Bar-plot, Pie-chart, Box plot, Stem-leaf, Histograms (equal class intervals and unequal class intervals), Frequency polygon, Ogives with graphical summaries of data.

Bachelor of Science (Hons.) in Statistics
STAT-SEC-3: Statistical Techniques for Research Methods

Credits: 4 **Marks: 100**

Course Objectives:
The learning objectives include:
- To provide scientific approaches to develop the domain of human knowledge through empirical studies.
- To enable the student researchers to understand basic concepts and aspects related to research, data collection, analyses and interpretation.

Course Learning Outcomes:
After completion of this course, students should have developed a clear understanding of:
- Research methodology.
- Research Problem.
- Research Designs.
- Comparative study of different methods of data collection.
- Guidelines for construction of questionnaires.
- Processing and Analysis of data.
- Interpretation and Report writing.

Contents:

UNIT I

Introduction: Meaning, objection and motivation in research, types of research, research approach, significance of research. Research problems: definition, selection and necessity of research problems.

UNIT II

Survey Methodology and Data Collection, inference and error in surveys, the target populations, sampling frames and coverage error, methods of data collection, non-response, questions and answers in surveys.

UNIT III

Processing, Data Analysis and Interpretation: Review of various techniques for data analysis covered in core statistics papers, techniques of interpretation, precaution in interpretation.

UNIT IV

Develop a questionnaire, collect survey data pertaining to a research problem (such as gender discriminations in private v/s government sector, unemployment rates, removal of subsidy, impact on service class v/s unorganized sectors), interpret the results and draw inferences.

SUGGESTED READINGS:

1. Kothari, C.R. (2015). *Research Methodology: Methods and Techniques*, 3rd Edition reprint, New Age International Publishers.
2. Kumar, R. (2011). *Research Methodology: A Step-by-Step Guide for Beginners*, SAGE publications.
3. Cochran, W.G. and Cox, G.M. (1959). *Experimental Design*. Asia Publishing House.

Project Work (using spread sheet and statistical packages –SPSS/R)

Week- wise Teaching Plan

Week 1	Research Methodology: Introduction, meaning of research, objectives of research, types of research, research approaches, research methods versus research methodology, research process. Research Problem: Importance and techniques involved in defining a research problem.
Week 2	Research Design: Important concepts relating to research design, different research design and basic principles of experimental design.
Week 3	Design of Sample Surveys: Census and sample survey, implications of a sample design, probability sampling, non-probability sampling. Practical Work-Introduction to a software package.
Week 4	Methods Of Data Collection: Primary and Secondary data, Collection of primary data, difference between questionnaires and schedules. Guidelines for constructing questionnaire and successful interviewing. Practical work.
Week 5	Data Preparation: Processing and Analysis of Data: Processing Operations, measures of central tendency and dispersion. Practical work.
Week 6	Sampling Fundamentals: Sampling and non-sampling errors, sampling distributions. Point and interval estimation. Practical work.
Week 7	Sampling Fundamentals: Point and interval estimation.Sample size and its determination. Practical work.
Week 8	Testing of Hypothesis: Basic concepts concerning testing of hypothesis. Test statistic, critical region, critical value and decision rule. Project work.
Week 9	Testing of Hypothesis: Important Parametric Tests. Hypothesis testing of Means, and Proportions. Project work /Practical work.
Week 10	Testing of Hypothesis: Hypothesis testing for Difference between Means and Proportions. Project work/ Practical work.
Week 11	Testing of Hypothesis: Hypothesis testing for variance and equality of variances of two normal populations. Project work/ Practical work
Week 12	Chi-Square Tests: Test of difference of more than two proportions, Test of Independence of Attributes. Project work/ Practical work.
Week 13	Chi-Square Tests: Test of Goodness of Fit. Interpretation and Report Writing: Meaning and technique of interpretation. Project Work/ Practical work.
Week 14	Interpretation and Report Writing: Steps involved in report writing and it's significance. Layout, mechanics and precautions for writing research reports. Submission of Project work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Introduction to research methodology and technique of defining a research problem.	Class room lectures and discussions.	Participation in class discussion.
I	The basic principles of Experimental Designs and introduction to different research designs.	Class room lectures and discussions.	Participation in class discussion.
II	Concept of Sampling Designs.	Class room lectures and discussions.	(i) Participation in class discussion. (ii) Identification of a research problem.
II	Methods of Data Collection.		
II	Guidelines for constructing Questionnaire and successful Interviewing.		
II	Guidelines for constructing Questionnaire and successful Interviewing.		
A*	Understanding of fundamentals of research methodology, research problem and research designs.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.
III	Understanding of Processing Operations.	Class room lectures and discussions.	(i) Participation in class discussion. (ii) Development of a Questionnaire. Identification of appropriate Test of Hypothesis, formulation of null hypothesis, appropriate analysis, interpretation of results and conclusion.
III	Descriptive and Inferential Analysis of data.		
III	Sampling Distributions. Parametric Tests of Hypotheses. Chi -square Test.	Practical work using a software package.	
B*	Understanding of Hypothesis Testing.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.
IV	Application of research methodology.	Project Work and its presentation.	Ability to analyse the data, interpret the result and draw conclusion.

* As per requirements of Internal Assessment forB.Sc. (Hons.).

Keywords: Research methodology, Research Design, Data Collection, Questionnaire, Hypothesis, Interpretation and Report Writing.

Bachelor of Science (Hons.) in Statistics
STAT SEC-4: Statistical Simulation Techniques

Credits: 4 **Marks: 100**

Course Objectives:
The objective of this course is to introduce the nuances of techniques involved in simulation studies as applicable to modeling of systems. The programming implementations will be completed using C/MATLAB/R.

Course Learning Outcomes:
After completing this course, students will possess skills concerning:
- Use of simulation to understand the behavior of real world systems.
- Ability to generate Pseudo-random numbers by the different methods.
- Random variable generation from theoretical distributions.
- Use of Monte Carlo methods and regenerative simulation.
- Ability to develop programs for the purpose of simulation.

Contents:

Unit I

Introduction: Systems, Models, Simulation and Monte Carlo Methods. Pseudo-random number generators; Statistical tests of Pseudo-random numbers.

Unit II

Random variate generation-The inverse transform method, Acceptance-Rejection method, Composition Method. Simulation of random vectors. Generation from Discrete and Continuous distributions; Transformation of random variables.

Unit III

Monte Carlo integration; Variance reduction techniques.

Unit IV

Regenerative simulation; Point Estimators and Confidence Intervals.

SUGGESTED READINGS:

4. Fishman, G.S. (1996). *Monte Carlo-Concepts, Algorithms and Applications*, Springer.
5. Rubinstein, R.Y. (1981). *Simulation and the Monte Carlo Methods*, Wiley.

6. Voss, J. (2014). *An introduction to statistical computing: a simulation-based approach,* Wiley series in computational statistics.

PRACTICAL/LAB WORK
List of Practicals:

1. Pseudo random number generators.
2. Generation of $U(0,1)$.
3. Problems based on statistical tests.
4. Application to standard statistical distributions (discrete and continuous):
   a) The inverse transform method.
   b) Acceptance-Rejection method.
5. Problems based on Composition Method.
6. Problems based on Monte Carlo integration.
7. Problems based on Regenerative methods.

Week-wise Teaching Plan

Week 1	Introduction: Systems, Models, Simulation and Monte Carlo Methods.
Week 2-3	Pseudo-random number generators. Practical work.
Week 4-5	Statistical tests of Pseudo-random numbers. Practical work.
Week 5-7	The Inverse transform& Acceptance-Rejection methods method-discrete distributions. Practical work.
Week 7-9	Inverse transform& Acceptance-Rejection methods-continuous distributions. Practical work.
Week 10	Composition Method. Practical work.
Week 11-12	Monte Carlo integration; Variance reduction techniques. Practical work.
Week 13-14	Regenerative simulation; Point Estimators and Confidence Intervals. Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Introduction: Systems, Models, Simulation and Monte Carlo Methods.	(i) Class room lectures and discussions.	(i) Participation in class discussion. (ii) Physical experimentation.
	Pseudo-random number generators.	(ii) Practical work.	
	Statistical tests of Pseudo-random numbers.		
II	Pseudo-random number generators.	(i) Class room lectures and	(i) Participation in class discussion.

	The inverse transform method-discrete distributions. The inverse transform method: continuous distributions. Composition Method.	discussions. (ii) Practical work.	(ii) Identification of random number, Monte-Carlo method, simulation worksheet, appropriate analysis, interpretation of results and conclusion.
A*	Appraisal-First.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.
III	Monte Carlo integration. Variance reduction techniques.	(i) Class room lectures and discussions. (ii) Practical work based.	(i) Participation in class discussion. (ii) Identification of random number, Monte- Carlo method, simulation worksheet, appropriate analysis, interpretation of results and conclusion.
IV	Regenerative simulation; Point Estimators and Confidence Intervals.		
B*	Appraisal-Second.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Simulation and Monte Carlo Methods, Random variate generation, Monte Carlo integration, Regenerative simulation.

Generic Elective Papers

Bachelor of Science (Hons.) in Statistics
STAT-GE-1: Statistical Methods

Credits: 6 **Marks:150**

Course Objectives:
The learning objectives include:
- Acquainting the students with various statistical methods.
- To introduce students to different measurement scales, qualitative and quantitative and discrete and continuous data.
- To help students to organize data into frequency distribution graphs, including bar graphs, histograms, polygons, and Ogives.
- Students should be able to understand the purpose for measuring central tendency, variation, skewness and kurtosis and should be able to compute them as well.
- Students should be able to understand and compute various statistical measures of correlation, fitting of curve and regression.

Course Learning Outcomes:
Upon successful completion of this course students will demonstrate knowledge of:
- Introduction to Statistics, definitions and data classification, types of studies and types of samples.
- Graphical displays of data, frequency distributions, analyzing graphs.
- Numerical descriptions of data, measures of center tendency, measures of dispersion, skewness and kurtosis.
- Correlation and regression.
- Theory of attributes.

Contents:

UNIT I

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.

UNIT II

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

UNIT III

Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.

UNIT IV

Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency.

SUGGESTED READINGS:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002). *Fundamentals of Statistics*, 8th Ed. Vol. I & II, The World Press, Kolkata.
2. Miller, I. and Miller, M. (2006). *John E. Freund's Mathematical Statistics with Applications*, 7th Ed., Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007). *Introduction to the Theory of Statistics,* 3rd Ed., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

PRACTICAL/ LAB WORK
List of Practicals:

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.
6. Fitting of polynomials, exponential curves.
7. Karl Pearson correlation coefficient.
8. Partial and multiple correlations.
9. Spearman rank correlation with and without ties.
10. Correlation coefficient for a bivariate frequency distribution.
11. Lines of regression, angle between lines and estimated values of variables.
12. Checking consistency of data and finding association among attributes.

Week-wise Teaching Plan:

Week 1	Introduction to statistics, development, importance and scope of statistics.
Week 2	Measurement scales and types of data. Practical work.
Week 3	Presentation of data by tables and graphs. Practical work.
Week 4-6	Measures of central tendency, cumulative frequency distributions. Practical work.
Week 6-7	Measures of dispersion. Practical work.
Week 8	Moments. Practical work.
Week 9	Measures of skewness and kurtosis. Practical work.
Week 10	Bivariate data scatter diagram, principle of least squares and curve fitting. Practical work.
Week 11	Pearson's correlation, rank correlation. Practical work.
Week 12	Regression. Practical work.
Week 13	Multiple and partial correlation. Practical work.
Week 14-15	Theory of attributes. Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Introduction to Statistics, development, importance and scope of statistics, scales of measurements and types of data.	Class room lectures and Practical work.	Participation in class discussion and completion of assignment.
I	Presentation of data by tables and graphs.	Class room lectures and Practical work.	Participation in class discussion and completion of assignment
II	Measures of central tendency, cumulative frequency distributions.	Class room lectures and Practical work.	Participation in class discussion and completion of assignment.
II	Measures of dispersion, moments, measures of skewness and kurtosis.		
A*	Understanding of basic concept of statistics, measures of central tendency, dispersion, moments, skewness and kurtosis.	Class test / Assignment work.	Extent of clarity in theoretical concepts.
III	Bivariate data, scatter diagram, Principle of least squares, curve fitting	Class room lectures and Practical.	Participation in class discussion and completion of assignment.
III	Pearson's correlation, rank correlation, multiple and partial correlation coefficients.		
III	Regression		
IV	Theory of attributes, independence and association of attributes.	Class room lectures and Practical.	Participation in class discussion and completion of assignment.
B*	Understanding the concepts correlation, principle of least square, curve fitting and regression.	Assignment work/ class test.	Extent of clarity in theoretical concepts.

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Statistical population and sample, Measures of central tendency, Bivariate data, Regression, Theory of attributes.

Bachelor of Science (Hons.) in Statistics

STAT-GE-2: Introductory Probability

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include:
- Understanding probability theory at basic and advance level, random variables and also their convergences at weak and strong levels.
- Different probability distribution (discrete and continuous).

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- The fundamental concepts of Probability Theory.
- Solving probabilistic problems.
- Understanding random variables and computing properties of distribution they follow.
- Different probability distributions and their implementation at realistic models.

Contents:

UNIT I

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

UNIT II

Random Variables: Discrete and continuous random variables, pmf, pdf,cdf. Illustrations of random variables and its properties. Expectation, variance, moments and moment generating function.

UNIT III

Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.).

UNIT IV

Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, beta, gamma.

SUGGESTED READINGS:
1. Hogg, R.V., Tanis, E.A. and Rao, J.M. (2009). *Probability and Statistical Inference*, 7th Ed, Pearson Education, New Delhi.
2. Miller, I. and Miller, M. (2006). *John E. Freund's Mathematical Statistics with Applications*, 7th Ed., Pearson Education, Asia.
3. Myer, P.L. (1970). *Introductory Probability and Statistical Applications*, Oxford & IBH

Publishing, New Delhi.

PRACTICAL/LAB WORK
List of Practicals:

1. Fitting of binomial distributions for n and p = q = ½ given.
2. Fitting of binomial distributions for n and p given.
3. Fitting of binomial distributions computing mean and variance.
4. Fitting of Poisson distributions for given value of lambda.
5. Fitting of Poisson distributions after computing mean.
6. Application problems based on binomial distribution.
7. Application problems based on Poisson distribution.
8. Problems based on area property of normal distribution.
9. To find the ordinate for a given area for normal distribution.
10. Application based problems using normal distribution.
11. Fitting of normal distribution when parameters are given.
12. Fitting of normal distribution when parameters are not given.

Week-wise Teaching Plan:

Week 1	Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic.
Week 2-3	Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability.
Week 4	Bayes' theorem and its applications.
Week 5-6	Random Variables: Discrete and continuous random variables, pmf, pdf, cdf. Illustrations of random variables and its properties.
Week 7-8	Expectation, variance, moments and moment generating function.
Week 9-10	Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers.
Week 11-12	De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.).
Week 13-14	Discrete probability distributions: Binomial, Poisson, Geometric, Negative-Binomial and Hypergeometric.
Week 15-16	Continuous probability distributions: Uniform, Normal, Exponential, Beta and Gamma.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability–classical, statistical, and axiomatic.	Class room lectures and discussions.	Participation in class discussion and problem solving.

I	Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability.		
I	Bayes' theorem and its applications.		
II	Random Variables: Discrete and continuous random variables, pmf, pdf, cdf. Illustrations of random variables and its properties.	Class room lectures and discussions.	Participation in class discussion and problem solving.
II	Expectation, variance, moments and moment generating function.		
III	Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers.	Class room lectures and discussions.	Participation in class discussion and problem solving.
III	De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.).		
IV	Discrete probability distributions: Binomial, Poisson, Geometric, Negative Binomial and Hypergeometric.	Class room lectures and discussions.	Participation in class discussion and problem solving.
IV	Continuous probability distributions: Uniform, Normal, Exponential, Beta and Gamma.		

Keywords: Random Variables**,** Discrete and Continuous Probability distributions along with their characteristic properties, Law of Large numbers.

Bachelor of Science (Hons.) in Statistics
STAT-GE-3: Basics of Statistical Inference

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include:
- To learn how the mathematical ideas of Statistics carry over into the world of applications.
- To analyse and interpret the data.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- Theory of estimation.
- Tests of hypothesis.
- Application of Chi-square test.
- Nonparametric tests.
- Analysis of variance.
- Fundamentals and analysis of basic designs (CRD, RCBD).
- Bioassay.

Contents:

UNIT I

Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems). The basic idea of significance test, Null and alternative hypothesis, Type I & Type II errors, level of significance, Concept of p-value, Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).

UNIT II

Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square Test, Yates' correction.

UNIT III

Tests for the significance of correlation coefficient, Sign test for median, Sign test for symmetry, Wilcoxon two-sample test.

UNIT IV

Analysis of variance, One-way and two-way classification; Brief exposure of three basic principles of design of experiments, treatment, plot and block; Analysis of completely randomized design; Randomized complete block design. Bioassay.

SUGGESTED REDINGS:

1. Bancroft, H. (1962). *Introduction to Bio-Statistics*, P.B. Hoebar, New York.
2. Daniel, Wayne W. (2005). *Bio-statistics: A Foundation for Analysis in the Health Sciences*, John Wiley.
3. Dass, M.N. and Giri, N.C. (1986). *Design and analysis of experiments*, John Wiley.
4. Goldstein, A. (1971). *Biostatistics-An introductory text*, The Macmillion, New York.
5. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): *Fundamentals of statistics,* Vol.-I & II, World Press, Kolkata.
6. Miller, I. and Miller, M. (2014). *Mathematical Statistics with Applications*, Pearson.

PRACTICAL/LAB WORK
List of Practicals:

1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Test for correlation coefficient.
8. Sign test for median.
9. Sign test for symmetry.
10. Wilcoxon two-sample test.
11. Analysis of Variance of a one way classified data
12. Analysis of Variance of a two way classified data.
13. Analysis of a CRD.
14. Analysis of an RBD.

Week-wise Teaching Plan:

Week 1-2	Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems). Practical work.
Week 3-5	The basic idea of significance test, Null and alternative hypothesis, Type I & Type II errors, level of significance, Concept of p-value, Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems). Practical work.
Week 6-7	Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square Test, Yates' correction. Practical work.
Week 8-9	Tests for the significance of correlation coefficient, Sign test for median, Sign test for symmetry, Wilcoxon two-sample test. Practical work.
Week 10-11	Analysis of variance, One-way and two-way classification. Practical work.
Week 12	Brief exposure of three basic principles of design of experiments, treatment, plot and block.
Week 13	Completely randomized design (CRD). Practical work.
Week 14	Randomized complete block design (RCBD). Practical work.
Week 15	Bioassay.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Problems of estimation.	Class room lectures and discussions. Practical Work.	Participation in class and discussion.
I	Hypothesis testing.	Class room lectures and discussions. Practical Work.	Participation in class and discussion.
A*	Understanding of estimation and hypothesis testing.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.
II	Applications of Chi-square test.	Class room lectures and discussions. Practical Work.	Participation in class and discussion.
III	Non-parametric tests.		
B*	Understanding of Chi-square test and Nonparametric tests.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.
IV	Analysis of variance, Fundamental concepts of Design of Experiments.	Class room lectures and discussions. Practical Work.	Participation in class and discussion.
IV	Completely randomized design (CRD), Randomized complete block design (RCBD), Bioassay.	Class room lectures and discussions. Practical Work.	Participation in class and discussion.
C*	Understanding of Analysis of variance; fundamentals and analysis of basic designs (CRD, RCBD), Bioassay.	Class Test/ Assignment work.	Extent of clarity in theoretical concepts.

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Problems of estimation, Test of significance, Categorical data, Completely randomized design , Randomized complete block design **,** Nonparametric tests.

Bachelor of Science (Hons.) in Statistics
STAT-GE-4: Applied Statistics

Credits: 6 **Marks: 150**

Course Objectives:
The learning objectives include:
- This course will help students to know the applications of Statistics and learn and apply these techniques in the core course of their study.
- This course will give exposure to four applied fields of statistics viz. Time Series, Index Numbers, Statistical Quality Control and Demographic methods.
- They will be having hands on practice of working on the data related to above mentioned fields.

Course Learning Outcomes:
After completing this course, students should have developed an understanding of:
- Time series data, components of time series data, study the behavior and identifying the variation due to different components in the data.
- They will study to identify and measure various components of time series data.
- The fundamental concepts of Index Numbers, Construction of price and quantity Index numbers.
- Construction of Wholesale and Consumer price Index and its significance.
- Statistical Quality Control, Use of Statistical methods in industrial research and practice.
- Chance and Assignable causes of variation in data.
- Statistical process control tools- Control charts for variables and attributes.
- To learn about different demographic methods. Measurement of mortality and fertility rates, reproduction and population growth measures.
- Construction and importance of Life Table.

Contents:

UNIT I

Economic Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series.Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and exponential).Measurement of seasonal variations by method of ratio to trend.

UNIT II

Index numbers: Introduction, Construction of price and quantity Index Numbers by Simple and Weighted Aggregate Method. Construction of price and quantity index numbers by Laspeyre’s, Paasche’s, Marshall-Edgeworth’s and Fisher’s Formula. Criteria for a good index number. Construction of wholesale price index number, fixed base index number and Consumer price indexnumber with interpretation. Uses and limitations of index numbers.

UNIT III

Statistical Quality Control: Importance of statistical methods in industrial research and practice. Determination of tolerance limits. Causes of variations in quality: Chance and Assignable. General theory of control charts, Process & Product control, Control charts for variables: $\bar{X}$ and R-charts. Control charts for attributes: p and c-charts.

UNIT IV

Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. Age and sex), IMR, Standardized death rates. Life (mortality) tables: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

SUGGESTED READINGS:

1. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008). *Fundamentals of Statistics*, Vol. II, 9th Ed., World Press, Kolkata.
2. Gupta, S.C. and Kapoor, V.K. (2014). *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand.
3. Mukhopadhyay, P. (1999). *Applied Statistics*, New Central Book Agency, Calcutta.
4. Montogomery, D.C. (2009). *Introduction to Statistical Quality Control*, 6^{th} ed., Wiley India Pvt. Ltd.

PRACTICAL/LAB WORK
List of Practicals:

1. Measurement of trend: Fitting of linear, quadratic trend, exponential curve and plotting of trend values and comparing with given data graphically.
2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparing with given data graphically.
3. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation.
4. Construction of wholesale price index number, fixed base index number and consumer price index number with interpretation.
5. Construction and interpretation of $\bar{X}$ and R-chart.
6. Construction and interpretation p-chart (fixed sample size) and c-chart.
7. Computation of measures of mortality.
8. Completion of life table.
9. Computation of measures of fertility and population growth.

Week-wise Teaching Plan:

Week 1-2	Introduction to Time Series, Components of time series, Decomposition of time series-Additive and multiplicative model with their merits and demerits.
Week 2-3	Illustrations of time series. Measurement of trend by method of free-hand curve, method of semi-averages. Method of least squares (Linear trend). Practical work.
Week 3-4	Measurement of trend by method of least squares (quadratic and exponential). Measurement of seasonal variations by method of ratio to trend. Practical work.
Week 5-6	Introduction to Index Numbers, Construction of price and quantity Index Numbers by Simple Aggregate Method and Weighted Aggregate Method, Comparison and interpretation. Practical work.
Week 7	Criteria of a good Index number. Construction of wholesale price index numbers, fixed base index numbers and consumer price index numbers with interpretation. Uses and limitations of index numbers. Practical work.
Week 8	Introduction to Statistical Quality Control, Use of Statistical methods in industrial research and practice. Causes of variations in quality: chance and Assignable with illustrations.
Week 9	General theory of control charts, process & product control Determination of tolerance limits. Practical work.
Week 10	Control charts for variables: X- bar and R-charts. Illustrations and Practical work.
Week 11	Control charts for attributes: p and c-charts Illustrations and Practical work.
Week 12	Introduction to Demographic Methods, measurement of population, rates and ratios of vital events.
Week 13	Measurement of mortality: Crude Death Rate, Specific Death Rate (w.r.t. Age and sex), Infant Mortality Rate, Standardized death rates. Practical work.
Week 14	Life (mortality) tables: Assumptions, Description and Construction of Life table. Uses of Life table. Practical work.
Week 15	Measurement of fertility and reproduction rate: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR. Comparison and Interpretation. Practical work.

Facilitating the Achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Time series data, components of time series data, study the behavior and identifying the variation due to different components in the data.	(i) Class room lectures and discussions.	Participation in class discussion.
I	Identify and measure various components of time series data.	(i)Class room lectures and discussions. (ii) Practical problems from	Participation in class discussion. Problem solving, Analyse and Interpret the results.

		the list of practical.	
II	Index Numbers, construction of price and quantity index numbers.	(i) Class room lectures and discussions. (ii) Practical problems from the list of practical.	Participation in class discussion. Problem solving, Analyse and Interpret the results.
II	Construction of wholesale and Consumer price Index and its significance.	(i) Class room lectures and discussions. (ii) Practical problems from the list of practical.	Participation in class discussion. Problem solving, Analyse and Interpret the results.
A*	Understanding basic concepts with relevance and importance of time series and index numbers.	Class Test/ Assignment work.	Extent of clarity of theoretical concepts studied in the course.
III	Statistical Quality Control, Use of Statistical methods in industrial research and practice. Chance and Assignable causes of variation in data.	(i) Class room lectures and discussions.	Participation in class discussion.
III	Statistical process control tools- Control charts for variables, attributes.	(i) Class room lectures and discussions. (ii) Practical problems from the list of practical.	Participation in class discussion. Problem solving, Analyse and Interpret the results.
IV	Different demographic methods. Measurement of mortality and fertility rates, reproduction and population growth measures.	(i) Class room lectures and discussions. (ii) Practical problems from the list of practical.	Participation in class discussion. Problem solving, Analyse and Interpret the results.
IV	Construction and importance of Life Table.	(i) Class room lectures and discussions. (ii) Practical problems from the list of practical.	Participation in class discussion. Problem solving, Analyse and Interpret the results.
B*	Understanding of complete	Class Test/	Extent of clarity of theoretical

	course.	Assignment work	concepts studied in the course.
C*	Application of Time Series, Index Numbers, Statistical Quality Control and Demographic Methods. (optional)	Project Work and its presentation.	Ability to apply concepts of Time Series, Index Numbers, Statistical Quality Control and Demographic Methods on practical data, understanding and giving solutions to a problem.

*As per requirements of Internal Assessment for B.Sc. (Hons.).

Keywords: Components and Decomposition of time series, Index Numbers, Control charts, Demographic Methods, Measurement of mortality, Life Table.

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NAME	AFFILATION/COLLEGE
Dr. Poonam Singh	DEPARTMENT OF STATISTICS
Dr. Ranjita Pandey	DEPARTMENT OF STATISTICS
Dr. Renu Garg	DEPARTMENT OF STATISTICS
Dr. Zuber Akhter	DEPARTMENT OF STATISTICS
Mrs. Raj kumari	SRI VENKATESHWARA COLLEGE
Dr. M.V.R. Prasada Rao	SRI VENKATESHWARA COLLEGE
Dr. Madhu Bala Jain	LADY SHRI RAM COLLEGE FOR WOMEN
Dr. Sudhir Kapoor	HINDU COLLEGE
Dr. Sunita Gupta	LADY SHRI RAM COLLEGE FOR WOMEN
Dr. Ritu Jain	PGDAV COLLEGE
Mrs. Savitri Sharma	KIRORIMAL COLLEGE
Dr. Renu kaul	LADY SHRI RAM COLLEGE FOR WOMEN
Dr. Vandana Sarin Walia	KIRORIMAL COLLEGE
Dr. Sarita Bansal	PGDAV COLLEGE
Dr. Gopa Karmakar	KIRORIMAL COLLEGE
Dr. Rashmi Goel	KIRORIMAL COLLEGE
Dr. I. J. Arora	PGDAV COLLEGE
Mrs. Jasvinder Goswami	PGDAV COLLEGE
Dr. D. Goswami	HINDU COLLEGE
Dr. Anita Bansal	RAMJAS COLLEGE
Dr. Shishir Kumar Jha	RAMJAS COLLEGE
Dr. Alka Sabhrawal	KIRORIMAL COLLEGE
Dr. Babita Goyal	RAMJAS COLLEGE
Dr. Seema Gupta	RAM LAL ANAND COLLEGE
Dr.Veena Budhraja	SRI VENKATESHWARA COLLEGE
Dr. Anuradha	LADY SHRI RAM COLLEGE FOR WOMEN
Dr. Aparna Pandey	PGDAV COLLEGE
Dr. Mukta Dutta Mazumder	RAM LAL ANAND COLLEGE
Mr. Shrawan Kumar	KIRORIMAL COLLEGE
Dr. Sanjoy Roy Chowdhary	LADY SHRI RAM COLLEGE FOR WOMEN
Mr. Rajesh Sachdeva	RAM LAL ANAND COLLEGE
Mrs. Seema Joshi	RAM LAL ANAND COLLEGE
Dr. Neena Mital	RAM LAL ANAND COLLEGE
Dr. Mukti Kant Shukla	SRI VENKATESHWARA COLLEGE
Dr. Kamal Nain	HINDU COLLEGE
Dr. Varuna Pandey	PGDAV COLLEGE

Dr. N. Pushkarna	RAMJAS COLLEGE
Dr. Rajkumari Bahl	RAMJAS COLLEGE
Dr. Mithlesh Kumar Jha	PGDAV COLLEGE
Dr. Narender Kumar	HINDU COLLEGE
Dr. Priyanka Aggarwal	HINDU COLLEGE
Dr. Kailash Kumar	LADY SHRI RAM COLLEGE FOR WOMEN
Anuradha Rajkonwar Chatiya	RAMJAS COLLEGE
Dr. V. Ravi	LADY SHRI RAM COLLEGE FOR WOMEN
Mr. Sanjay Kumar Singh	PGDAV COLLEGE
Dr. Manoj Kumar Varshney	HINDU COLLEGE
Dr. Rita Jain	RAM LAL ANAND COLLEGE
Dr. Archana Verma	MATA SUNDRI COLLEGE FOR WOMAN
Mr. Vishal Deo	RAMJAS COLLEGE
Dr. Anupam Pathak	RAMJAS COLLEGE
Dr. Gajraj Singh	RAMJAS COLLEGE
Dr. Barnali Deka	RAMJAS COLLEGE
Ms. Neha Midha	HINDU COLLEGE
Mr. Lalit Kumar	LADY SHRI RAM COLLEGE FOR WOMEN
Dr. Meenu Goel	MATA SUNDRI COLLEGE FOR WOMAN
Mr. Nilesh Kumar (Research Scholar)	DEPARTMENT OF STATISTICS
Ms. Rashmi Sharma (Research Scholar)	DEPARTMENT OF STATISTICS

UNIVERSITY OF DELHI

BACHELOR OF SCIENCE (HONS.) IN MATHEMATICS

(B.Sc. (Hons.) Mathematics)

Learning Outcomes based Curriculum Framework (LOCF)

2019

Table of Contents

1. Introduction

The current focus in higher education is to shift from teacher-centric approach to learner-centric approach. For this as one of the aims, UGC has introduced the learning outcomes-based curriculum framework for undergraduate education. The learning outcomes-based curriculum framework for B.Sc. (Hons.) Mathematics is prepared keeping this in view. The framework is expected to provide a student with knowledge and skills in mathematics along with generic and transferable skills in other areas that help in personal development, employment and higher education in the global world. The programme-learning outcomes and course learning outcomes have been clearly specified to help prospective students, parents and employers understand the nature and extent of the degree programme; to maintain national and international standards, and to help in student mobility.

2. Learning Outcomes based approach to Curriculum Planning

The learning outcomes-based curriculum framework for B.Sc. (Hons.) Mathematics is based on the expected learning outcomes and graduate attributes that a graduate in mathematics is expected to attain. The curriculum for B.Sc. (Hons.) Mathematics is prepared keeping in mind the needs and aspirations of students in mathematics as well as the evolving nature of mathematics as a subject. The course learning outcomes and the programme learning outcomes specify the knowledge, understanding, skills, attitudes and values that a student completing this degree is expected to know. The qualification of B.Sc. (Hons.) Mathematics is awarded to a student who can demonstrating the attainment of these outcomes.

2.1 Nature and extent of the B.Sc. (Hons.) Mathematics

Mathematics is usually described as the abstract science of number, quantity and space along with their operations. The scope of Mathematics is very broad and it has a wide range of applications in natural sciences, engineering, economics and social sciences. B.Sc. (Hons.) Mathematics Programme aims at developing the ability to think critically, logically and analytically and hence use mathematical reasoning in everyday life. Pursuing a degree in mathematics will introduce the students to a number of interesting and useful ideas in preparations for a number of mathematics careers in education, research, government sector, business sector and industry.

The B.Sc. (Hons.) Mathematics programme covers the full range of mathematics, from classical Calculus to Modern Cryptography, Information Theory, and Network Security. The course lays a structured foundation of Calculus, Real & Complex analysis, Abstract Algebra, Differential Equations (including Mathematical Modelling), Number Theory, Graph Theory, and C++ Programming exclusively for Mathematics.

An exceptionally broad range of topics covering Pure & Applied Mathematics: Linear Algebra, metric Spaces, Statistics, Linear Programming, Numerical Analysis, Mathematicl Fi nance, Coding Theory, Mechanics and Biomathematics cater to varied interests and ambitions. Also hand on sessions in Computer Lab using various Computer Algebra Systems (CAS) softwares such as Mathematica, MATLAB, Maxima, **R** to have a deep conceptual understanding of the above tools are carried out to widen the horizon of students' self-experience. The courses like Biomathematics, Mathematical Finance etc. emphasize on the relation of mathematics to other subjects like Biology, Economics and Finance.

To broaden the interest for interconnectedness between formerly separate disciplines one can choose from the list of Generic electives for example one can opt for economics as one of the GE papers. Skill enhancement Courses enable the student acquire the skill relevant to the main subject. Choices from Discipline Specific Electives provides the student with liberty of exploring his interests within the main subject.

Of key importance is the theme of integrating mathematical and professional skills. The well-structured programme empowers the student with the skills and knowledge leading to enhanced career opportunities in industry, commerce, education, finance and research.

2.2 Aims of Bachelor's degree programme in Mathematics

The overall aims of B.Sc.(Hons) Mathematics Programme are to:

- inculcate strong interest in learning mathematics.
- evolve broad and balanced knowledge and understanding of definitions, key concepts, principles and theorems in Mathematics
- enable learners/students to apply the knowledge and skills acquired by them during the programme to solve specific theoretical and applied problems in mathematics.
- develop in students the ability to apply relevant tools developed in mathematical theory to handle issues and problems in social and natural sciences.
- provide students with sufficient knowledge and skills that enable them to undertake further studies in mathematics and related disciplines
- enable students to develop a range of generic skills which will be helpful in wage-employment, self-employment and entrepreneurship.

3. Graduate Attributes in Mathematics

Some of the graduate attributes in mathematics are listed below:

3.1 Disciplinary knowledge: Capability of demonstrating comprehensive knowledge of basic concepts and ideas in mathematics and its subfields, and its applications to other disciplines.

3.2 Communications skills: Ability to communicate various concepts of mathematics in effective and coherent manner both in writing and orally, ability to present the complex mathematical ideas in clear, precise and confident way, ability to explain the development and importance of mathematics and ability to express thoughts and views in mathematically or logically correct statements.

3.3 Critical thinking and analytical reasoning: Ability to apply critical thinking in understanding the concepts in mathematics and allied areas; identify relevant assumptions, hypothesis, implications or conclusions; formulate mathematically correct arguments; ability to analyse and generalise specific arguments or empirical data to get broader concepts.

3.4 Problem solving: Capacity to use the gained knowledge to solve different kinds of non-familiar problems and apply the learning to real world situations; Capability to solve problems in computer graphics using concepts of linear algebra; Capability to apply the knowledge gained in differential equations to solve specific problems or models in operations research, physics, chemistry, electronics, medicine, economics, finance etc.

3.5 Research-related skills: Capability to ask and inquire about relevant/appropriate questions, ability to define problems, formulate hypotheses, test hypotheses, formulate mathematical arguments and proofs, draw conclusions; ability to write clearly the results obtained.

3.6 Information/digital literacy: Capacity to use ICT tools in solving problems or gaining knowledge; capacity to use appropriate softwares and programming skills to solve problems in mathematics,

3.7 Self-directed learning: Ability to work independently, ability to search relevant resources and e-content for self-learning and enhancing knowledge in mathematics.

3.8 Moral and ethical awareness/reasoning: Ability to identify unethical behaviour such as fabrication or misrepresentation of data, committing plagiarism, infringement of intellectual property rights.

3.9 Lifelong learning: Ability to acquire knowledge and skills through self-learning that helps in personal development and skill development suitable for changing demands of work place.

4. Qualification descriptors for B.Sc. (Hons.) Mathematics

Students who choose B.Sc. (Hons.) Mathematics Programme, develop the ability to think critically, logically and analytically and hence use mathematical reasoning in everyday life.

Pursuing a degree in mathematics will introduce the students to a number of interesting and useful ideas in preparations for a number of mathematics careers in education, research, government sector, business sector and industry.

The programme covers the full range of mathematics, from classical Calculus to Modern Cryptography, Information Theory, and Network Security. The course lays a structured foundation of Calculus, Real & Complex analysis, Abstract Algebra, Differential Equations (including Mathematical Modeling), Number Theory, Graph Theory, and C++ Programming exclusively for Mathematics.

An exceptionally broad range of topics covering Pure & Applied Mathematics: Linear Algebra, Metric Spaces, Statistics, Linear Programming, Numerical Analysis, Mathematical Finance, Coding Theory, Mechanics and Biomathematics cater to varied interests and ambitions. Also hand on sessions in Computer Lab using various Computer Algebra Systems (CAS) softwares such as Mathematica, MATLAB, Maxima, **R** to have a deep conceptual understanding of the above tools are carried out to widen the horizon of students' self-experience.

To broaden the interest for interconnectedness between formerly separate disciplines one can choose from the list of Generic electives for example one can opt for economics as one of the GE papers. Skill enhancement courses enable the student acquire the skill relevant to the main subject. Choices from Discipline Specific Electives provides the student with liberty of exploring his interests within the main subject.

Of key importance is the theme of integrating mathematical and professional skills. The well-structured programme empowers the student with the skills and knowledge leading to enhanced career opportunities in industry, commerce, education, finance and research. The qualification descriptors for B.Sc. (Hons.) Mathematics may include the following:

i. demonstrate fundamental/systematic and coherent knowledge of the academic field of mathematics and its applications and links to engineering, science, technology, economics and finance; demonstrate procedural knowledge that create different professionals like teachers and researchers in mathematics, quantitative analysts, actuaries, risk managers, professionals in industry and public services.
ii. demonstrate educational skills in areas of analysis, geometry, algebra, mechanics, differential equations etc.
iii. demonstrate comprehensive knowledge about materials, including scholarly, and/or professional literature, relating to essential learning areas pertaining to the field of mathematics, and techniques and skills required for identifying mathematical problems.
iv. Apply the acquired knowledge in mathematics and transferable skills to new/unfamiliar contexts and real-life problems.
v. Demonstrate mathematics-related and transferable skills that are relevant to some of the job trades and employment opportunities.

5. Programme Learning Outcomes in B.Sc. (Hons.) Mathematics

The completion of the B.Sc. (Hons.) Mathematics Programme will enable a student to:

i) Communicate mathematics effectively by written, computational and graphic means.
ii) Create mathematical ideas from basic axioms.
iii) Gauge the hypothesis, theories, techniques and proofs provisionally.
iv) Utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis.
v) Identify applications of mathematics in other disciplines and in the real-world, leading to enhancement of career prospects in a plethora of fields and research.

6. Structure of B.Sc. (Hons.) Mathematics

The B.Sc. (Hons.) Mathematics programme is a three-year, six-semesters course. A student is required to complete 148 credits for completion of the course.

		Semester	**Semester**
Part – I	First Year	Semester I: 22	Semester II: 22
Part – II	Second Year	Semester III: 28	Semester IV: 28
Part - III	Third Year	Semester V: 24	Semester VI: 24

Semester wise Details of B.Sc. (Hons.) Mathematics Course & Credit Scheme

Sem-ester	**Core Course(14)**	**Ability Enhancement Compulsory Course (AECC)(2)**	**Skill Enhancement Course (SEC)(2)**	**Discipline Specific Elective (DSE)(4)**	**Generic Elective (GE)(4)**	**Total Credits**
I	BMATH101:Calculus (including practicals) BMATH102: Algebra	(English Communication/MIL)/ Environmental Science			GE-1	
L+T/P	4 + 2 = 6; 5 + 1 = 6	4			5+1 = 6	22
II	BMATH203: Real Analysis BMATH204: Differential Equations (including practicals)	(English Communication/MIL)/ Environmental Science			GE-2	
L+T/P	5 + 1 = 6; 4 + 2 = 6	4			5+1 = 6	22

Semester	Core Course(14)	Ability Enhancement Compulsory Course (AECC)(2)	Skill Enhancement Course (SEC)(2)	Discipline Specific Elective (DSE)(4)	Generic Elective (GE)(4)	Total Credits
III	BMATH305: Theory of Real Functions BMATH306: Group Theory-I BMATH307: Multivariate Calculus (including practicals)		SEC-1 LaTeX and HTML		GE-3	
L+T/P	5 + 1 = 6; 5 + 1 = 6; 4 + 2 = 6		4		5 +1 = 6	28
IV	BMATH408: Partial Differential Equations (including practicals) BMATH409: Riemann Integration and Series of Functions BMATH410: Ring Theory and Linear Algebra-I		SEC-2 Computer Algebra Systems and Related Software		GE-4	
L+T/P	4 + 2 = 6; 5 + 1 = 6; 5 + 1 = 6		4		5 +1 = 6	28
V	BMATH511: Metric Spaces BMATH512: Group Theory-II			DSE-1 (including practicals) DSE-2		
L+T/P	5 + 1 = 6; 5 + 1 = 6			4 + 2 = 6; 5 + 1 = 6		24
VI	BMATH613: Complex Analysis (including practicals) BMATH614: Ring Theory and Linear Algebra-II			DSE-3 DSE-4		
L+T/P	4 + 2 = 6; 5 + 1 = 6			5 + 1 = 6; 5 + 1 = 6		24

Total Credits = 148

Legend: L: Lecture Class; T: Tutorial Class; P: Practical Class
Note: One-hour lecture per week equals 1 Credit, 2 Hours practical class per week equals 1 credit. Practical in a group of 15-20 students in Computer Lab and Tutorial in a group of 8-12 students.

List of Discipline Specific Elective (DSE) Courses:

DSE-1 (Including Practicals): Any *one* of the following
(at least *two* shall be offered by the college)

(i) Numerical Analysis
(ii) Mathematical Modeling and Graph Theory
(iii) C++ Programming for Mathematics

DSE-2: Any *one* of the following
(at least *two* shall be offered by the college)

(i) Probability Theory and Statistics
(ii) Discrete Mathematics
(iii) Cryptography and Network Security

DSE-3: Any *one* of the following
(at least *two* shall be offered by the college)

(i) Mathematical Finance
(ii) Introduction to Information Theory and Coding
(iii) Biomathematics

DSE-4: Any *one* of the following
(at least *two* shall be offered by the college)

(i) Number Theory
(ii) Linear Programming and Applications
(iii) Mechanics

Semester-I

BMATH101: Calculus

Total Marks: 150 (Theory: 75, Internal Assessment: 25 and Practical: 50)
Workload: 4 Lectures, 4 Practicals (per week) **Credits:** 6 (4+2)
Duration: 14 Weeks (56 Hrs. Theory + 56 Hrs. Practical) **Examination:** 3 Hrs.

Course Objectives: The primary objective of this course is to introduce the basic tools of calculus and geometric properties of different conic sections which are helpful in understanding their applications in planetary motion, design of telescope and to the real-world problems. Also, to carry out the hand on sessions in computer lab to have a deep conceptual understanding of the above tools to widen the horizon of students' self-experience.

Course Learning Outcomes: This course will enable the students to:

i) Learn first and second derivative tests for relative extrema and apply the knowledge in problems in business, economics and life sciences.
ii) Sketch curves in a plane using its mathematical properties in the different coordinate systems of reference.
iii) Compute area of surfaces of revolution and the volume of solids by integrating over cross-sectional areas.
iv) Understand the calculus of vector functions and its use to develop the basic principles of planetary motion.

Unit 1: Derivatives for Graphing and Applications
The first-derivative test for relative extrema, Concavity and inflection points, Second-derivative test for relative extrema, Curve sketching using first and second derivative tests; Limits to infinity and infinite limits, Graphs with asymptotes, L'Hôpital's rule; Applications in business, economics and life sciences; Higher order derivatives, Leibniz rule.

Unit 2: Sketching and Tracing of Curves
Parametric representation of curves and tracing of parametric curves (except lines in $\mathbb{R}^3$), Polar coordinates and tracing of curves in polar coordinates; Techniques of sketching conics, Reflection properties of conics, Rotation of axes and second degree equations, Classification into conics using the discriminant.

Unit 3: Volume and Area of Surfaces
Volumes by slicing disks and method of washers, Volumes by cylindrical shells, Arc length, Arc length of parametric curves, Area of surface of revolution; Hyperbolic functions; Reduction formulae.

Unit 4: Vector Calculus and its Applications
Introduction to vector functions and their graphs, Operations with vector functions, Limits and continuity of vector functions, Differentiation and integration of vector functions; Modeling ballistics and planetary motion, Kepler's second law; Unit tangent, Normal and binormal vectors, Curvature.

References:

1. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). *Calculus* (10th ed.). John Wiley & Sons Singapore Pte. Ltd. Indian Reprint (2016) by Wiley India Pvt. Ltd. Delhi.
2. Prasad, Gorakh (2016). *Differential Calculus* (19th ed.). Pothishala Pvt. Ltd. Allahabad.
3. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). *Calculus* (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.

Additional Reading:

i. Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014). *Thomas*' *Calculus* (13th ed.). Pearson Education, Delhi. Indian Reprint 2017.

Practical / Lab work to be performed in Computer Lab.

List of the practicals to be done using Mathematica /MATLAB /Maple/Scilab/Maxima etc.

1. Plotting the graphs of the following functions:
$$ax,\ [x](\text{greatest integer function}), \sqrt{ax+b},\ |ax+b|, c \pm\ |ax+b|,$$
$$x^{\pm n}, x^{\frac{1}{n}}\ (n \in \mathbb{Z}),\ \frac{|x|}{x}, \sin\left(\frac{1}{x}\right), x\sin\left(\frac{1}{x}\right), \text{and}\ \ e^{\pm\frac{1}{x}}, \text{for } x \neq 0,$$
$$e^{ax+b}, \log\ (ax+b), 1/(ax+b), \sin\ (ax+b), \cos(\ ax+b),$$
$$|\sin(\ ax+b)|, |\cos(\ ax+b)|.$$
Observe and discuss the effect of changes in the real constants *a*, *b* and *c* on the graphs.
2. Plotting the graphs of polynomial of degree 4 and 5, and their first and second derivatives, and analysis of these graphs in context of the concepts covered in Unit 1.
3. Sketching parametric curves, e.g., trochoid, cycloid, epicycloid and hypocycloid.
4. Tracing of conics in Cartesian coordinates.
5. Obtaining surface of revolution of curves.
6. Graph of hyperbolic functions.
7. Computation of limit, Differentiation, Integration and sketching of vector-valued functions.
8. Complex numbers and their representations, Operations like addition, multiplication, division, modulus. Graphical representation of polar form.
9. Find numbers between two real numbers and plotting of finite and infinite subset of $\mathbb{R}$.
10. Matrix operations: addition, multiplication, inverse, transpose; Determinant, Rank, Eigenvectors, Eigenvalues, Characteristic equation and verification of the Cayley–Hamilton theorem, Solving the systems of linear equations.

Teaching Plan (Theory of BMATH101: Calculus):

Week 1: The first-derivative test for relative extrema, Concavity and inflection points, Second-derivative test for relative extrema, Curve sketching using first and second derivative tests.

[3] Chapter 4 (Section 4.3).

Week 2: Limits to infinity and infinite limits, Graphs with asymptotes, Vertical tangents and cusps, L'Hôpital's rule.

[3] Chapter 4 (Sections 4.4 and 4.5).

Week 3: Applications of derivatives in business, economics and life sciences. Higher order derivatives and Leibniz rule for higher order derivatives for the product of two functions.

[3] Chapter 4 (Section 4.7).

[2] Chapter 5 (Sections 5.1, 5.2 and 5.4).

Week 4: Parametric representation of curves and tracing of parametric curves (except lines in $\mathbb{R}^3$), Polar coordinates and the relationship between Cartesian and polar coordinates.

[3] Chapter 9 [Section 9.4 (Pages 471 to 475)].

[1] Chapter 10 (Sections 10.1, and 10.2 up to Example 2, Page 707).

Weeks 5 and 6: Tracing of curves in polar coordinates. Techniques of sketching conics**:** parabola, ellipse and hyperbola.

[1] Sections 10.2 (Pages 707 to 717), and 10.4 up to Example 10 Page 742)].

Week 7: Reflection properties of conics, Rotation of axes, Second degree equations and their classification into conics using the discriminant.

[1] Sections 10.4 (Pages 742 to 744) and 10.5.

Weeks 8 and 9: Volumes by slicing disks and method of washers, Volumes by cylindrical shells, Arc length, Arc length of parametric curves.

[1] Chapter 5 (Sections 5.2, 5.3 and 5.4).

Week 10: Area of surface of revolution; Hyperbolic functions.

[1] Sections 5.5 and 6.8.

Week 11: Reduction formulae, and to obtain the iterative formulae for the integrals of the form**:** $\int \sin^n x\,dx$, $\int \cos^n x\,dx$, $\int \tan^n x\,dx$, $\int \sec^n x\,dx$ and $\int \sin^m x \cos^n x\,dx$.

[1] Chapter 7 [Sections 7.2 and 7.3 (Pages 497 to 503)].

Week 12: Introduction to vector functions and their graphs, Operations with vector functions, Limits and continuity of vector functions, Differentiation and tangent vectors.

[3] Chapter 10 (Sections 10.1 and 10.2 up to Page 504).

Week 13: Properties of vector derivatives and integration of vector functions; Modeling ballistics and planetary motion, Kepler's second law.

[3] Chapter 10 [Sections 10.2 (Pages 505 to 511) and 10.3].

Week 14: Unit tangent, Normal and binormal vectors, Curvature.

[1] Sections 12.4 and 12.5.

Facilitating the Achievement of Course Learning Outcomes

<table>
<tr><th>Unit No.</th><th>Course Learning Outcomes</th><th>Teaching and Learning Activity</th><th>Assessment Tasks</th></tr>
<tr><td>1.</td><td>Learn first and second derivative tests for relative extrema and apply the knowledge in problems in business, economics and life sciences.</td><td rowspan="4">(i) Each topic to be explained with illustrations.
(ii) Students to be encouraged to discover the relevant concepts.
(iii) Students be given homework/assignments.
(iv) Discuss and solve the theoretical and practical problems in the class.
(v) Students to be encouraged to apply concepts to real world problems.</td><td rowspan="4">• Presentations and class discussions.
• Assignments and class tests.
• Student presentations.
• Mid-term examinations.
• Practical and viva-voce examinations.
• End-term examinations.</td></tr>
<tr><td>2.</td><td>Sketch curves in a plane using its mathematical properties in the different coordinate systems of reference.</td></tr>
<tr><td>3.</td><td>Compute area of surfaces of revolution and the volume of solids by integrating over cross-sectional areas.</td></tr>
<tr><td>4.</td><td>Understand the calculus of vector functions and its use to develop the basic principles of planetary motion.</td></tr>
</table>

Keywords: Concavity, Extrema, Inflection point, Hyperbolic functions, Leibniz rule, L'Hôpital's rule, Polar and parametric coordinates, Vector functions.

BMATH102: Algebra

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: The primary objective of this course is to introduce the basic tools of theory of equations, complex numbers, number theory and matrices to understand their connection with the real-world problems. Perform matrix algebra with applications to computer graphics.

Course Learning Outcomes: This course will enable the students to:

i) Employ De Moivre's theorem in a number of applications to solve numerical problems.
ii) Learn about equivalent classes and cardinality of a set.
iii) Use modular arithmetic and basic properties of congruences.
iv) Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix.
v) Find eigenvalues and corresponding eigenvectors for a square matrix.

Unit 1: Theory of Equations and Complex Numbers
Polynomials, The remainder and factor theorem, Synthetic division, Factored form of a polynomial, Fundamental theorem of algebra, Relations between the roots and the coefficients of polynomial equations, Theorems on imaginary, integral and rational roots; Polar representation of complex numbers, De Moivre's theorem for integer and rational indices and their applications. The nth roots of unity.

Unit 2: Equivalence Relations and Functions
Equivalence relations, Functions, Composition of functions, Invertibility and inverse of functions, One-to-one correspondence and the cardinality of a set.

Unit 3: Basic Number Theory
Well ordering principle, The division algorithm in $\mathbb{Z}$, Divisibility and the Euclidean algorithm, Fundamental theorem of arithmetic, Modular arithmetic and basic properties of congruences; Principle of mathematical induction.

Unit 4: Row Echelon Form of Matrices and Applications
Systems of linear equations, Row reduction and echelon forms, Vector equations, The matrix equation $A\mathbf{x} = b$, Solution sets of linear systems, The inverse of a matrix; Subspaces, Linear independence, Basis and dimension, The rank of a matrix and applications; Introduction to linear transformations, The matrix of a linear transformation; Applications to computer graphics, Eigenvalues and eigenvectors, The characteristic equation and Cayley–Hamilton theorem.

References:

1. Andreescu, Titu & Andrica Dorin. (2014). *Complex Numbers from A to...Z.* (2nd ed.). Birkhäuser.

2. Dickson, Leonard Eugene (2009). *First Course in the Theory of Equations*. The Project Gutenberg EBook (http://www.gutenberg.org/ebooks/29785)
3. Goodaire, Edgar G., & Parmenter, Michael M. (2005). *Discrete Mathematics with Graph Theory* (3rd ed.). Pearson Education Pvt. Ltd. Indian Reprint 2015.
4. Kolman, Bernard, & Hill, David R. (2001). *Introductory Linear Algebra with Applications* (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.
5. Lay, David C., Lay, Steven R., & McDonald, Judi J. (2016). *Linear Algebra and its Applications* (5th ed.). Pearson Education.

Additional Readings:

i. Andrilli, Stephen, & Hecker, David (2016). *Elementary Linear Algebr*a (5th ed.). Academic Press, Elsevier India Private Limited.
ii. Burton, David M. (2012). *Elementary Number Theory* (7th ed.). McGraw-Hill Education Pvt. Ltd. Indian Reprint.

Teaching Plan (BMATH102: Algebra):

Weeks 1 and 2: Polynomials, The remainder and factor theorem, Synthetic division, Factored form of a polynomial, Fundamental theorem of algebra, Relations between the roots and the coefficients of polynomial equations, Theorems on imaginary, integral and rational roots.

[2] Chapter II (Sections 12 to 16, 19 to 21, 24 and 27, Statement of the Fundamental theorem of algebra).

Weeks 3 and 4: Polar representation of complex numbers, De Moivre's theorem for integer and rational indices and their applications, The *n*th roots of unity.

[1] Chapter 2 [Section 2.1(2.1.1 to 2.1.3), Section 2.2 (2.2.1, 2.2.2 (up to Page 45, without propositions), 2.2.3].

Weeks 5 and 6. Equivalence relations, Functions, Composition of functions, Invertibility and inverse of functions, One-to-one correspondence and the cardinality of a set.

[3] Chapter 2 (Section 2.4 (2.4.1 to 2.4.4)), and Chapter 3.

Weeks 7 and 8: Well ordering principle, The division algorithm in $\mathbb{Z}$, Divisibility and the Euclidean algorithm, Modular arithmetic and basic properties of congruences, Statements of the fundamental theorem of arithmetic and principle of mathematical induction.

[3] Chapter 4 [Sections 4.1 (4.1.2,4.1.5,4.1.6), 4.2 (4.2.1 to 4.2.11, up to problem 11), 4.3 (4.3.7 to 4.3.9), 4.4 (4.4.1 to 4.4.8)], and Chapter 5 (Section 5.1.1).

Weeks 9 and 10: Systems of linear equations, Row reduction and echelon forms, Vector equations, The matrix equation $A\mathbf{x} = b$, Solution sets of linear systems, The inverse of a matrix.

[5] Chapter 1 (Sections 1.1 to 1.5) and Chapter 2 (Section 2.2).

Week 11 and 12: Subspaces, Linear independence, Basis and dimension, The rank of a matrix and applications.

[4] Chapter 6 (Sections 6.2, 6.3, 6.4, and 6.6).

Weeks 13: Introduction to linear transformations, Matrix of a linear transformation; Applications to computer graphics.

[5] Chapter 1 (Sections 1.8 and 1.9), and Chapter 2 (Section 2.7).

Week 14: Eigenvalues and eigenvectors, The characteristic equation and Cayley–Hamilton theorem.

[5] Chapter 5 (Sections 5.1 and 5.2, Supplementary Exercises 5 and 7, Page 328).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Employ De Moivre's theorem in a number of applications to solve	(i) Each topic to be explained with examples.	• Student

	numerical problems.	(ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be encouraged to give short presentations.	presentations. • Participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Learn about equivalent classes and cardinality of a set.		
3.	Use modular arithmetic and basic properties of congruences.		
4.	Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix. Find eigenvalues and corresponding eigenvectors for a square matrix.		

Keywords: Cardinality of a set, Cayley–Hamilton theorem, De Moivre's theorem, Eigenvalues and eigenvectors, Equivalence relations, Modular arithmetic, Row echelon form, The Fundamental theorem of algebra.

Semester-II

BMATH203: Real Analysis

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: The course will develop a deep and rigorous understanding of real line $\mathbb{R}$. and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. These concepts have wide range of applications in real life scenario.

Course Learning Outcomes: This course will enable the students to:

i) Understand many properties of the real line $\mathbb{R}$, including completeness and Archimedean properties.
ii) Learn to define sequences in terms of functions from $\mathbb{N}$ to a subset of $\mathbb{R}$.
iii) Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
iv) Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

Unit 1: Real Number System $\mathbb{R}$
Algebraic and order properties of $\mathbb{R}$, Absolute value of a real number; Bounded above and bounded below sets, Supremum and infimum of a nonempty subset of $\mathbb{R}$.

Unit 2: Properties of $\mathbb{R}$
The completeness property of $\mathbb{R}$, Archimedean property, Density of rational numbers in $\mathbb{R}$; Definition and types of intervals, Nested intervals property; Neighborhood of a point in $\mathbb{R}$, Open and closed sets in $\mathbb{R}$.

Unit 3: Sequences in $\mathbb{R}$
Convergent sequence, Limit of a sequence, Bounded sequence, Limit theorems, Monotone sequences, Monotone convergence theorem, Subsequences, Bolzano−Weierstrass theorem for sequences, Limit superior and limit inferior for bounded sequence, Cauchy sequence, Cauchy's convergence criterion.

Unit 4: Infinite Series
Convergence and divergence of infinite series of real numbers, Necessary condition for convergence, Cauchy criterion for convergence; Tests for convergence of positive term series**:** Integral test, Basic comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy's *n*th root test; Alternating series, Leibniz test, Absolute and conditional convergence.

References:
1. Bartle, Robert G., & Sherbert, Donald R. (2015). *Introduction to Real Analysis* (4th ed.). Wiley India Edition. New Delhi.
2. Bilodeau, Gerald G., Thie, Paul R., & Keough, G. E. (2010). *An Introduction to Analysis* (2nd ed.). Jones & Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.

3. Denlinger, Charles G. (2011). *Elements of Real Analysis*. Jones & Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.

Additional Readings:

i. Ross, Kenneth A. (2013). *Elementary Analysis*: *The Theory of Calculus* (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian Reprint.
ii. Thomson, Brian S., Bruckner, Andrew. M., & Bruckner, Judith B. (2001). *Elementary Real Analysis.* Prentice Hall.

Teaching Plan (BMATH203: Real Analysis):

Weeks 1 and 2: Algebraic and order properties of ℝ. Absolute value of a real number; Bounded above and bounded below sets, Supremum and infimum of a nonempty subset of ℝ.
[1] Chapter 2 [Sections 2.1, 2.2 (2.2.1 to 2.2.6) and 2.3 (2.3.1 to 2.3.5)]

Weeks 3 and 4: The completeness property of ℝ, Archimedean property, Density of rational numbers in ℝ, Definition and types of intervals, Nested intervals property; Neighborhood of a point in ℝ, Open and closed sets in ℝ.
[1] Sections 2.3 (2.3.6), 2.4 (2.4.3 to 2.4.9), and 2.5 up to Theorem 2.5.3.
[1] Chapter 11 [Section 11.1 (11.1.1 to 11.1.3)].

Weeks 5 and 6: Sequences and their limits, Bounded sequence, Limit theorems.
[1] Sections 3.1, 3.2.

Week 7: Monotone sequences, Monotone convergence theorem and applications.
[1] Section 3.3.

Week 8: Subsequences and statement of the Bolzano−Weierstrass theorem. Limit superior and limit inferior for bounded sequence of real numbers with illustrations only.
[1] Chapter 3 [Section 3.4 (3.4.1 to 3.4.12), except 3.4.4, 3.4.7, 3.4.9 and 3.4.11].

Week 9: Cauchy sequences of real numbers and Cauchy's convergence criterion.
[1] Chapter 3 [Section 3.5 (3.5.1 to 3.5.6)].

Week 10: Convergence and divergence of infinite series, Sequence of partial sums of infinite series, Necessary condition for convergence, Cauchy criterion for convergence of series.
[3] Section 8.1.

Weeks 11 and 12: Tests for convergence of positive term series**:** Integral test statement and convergence of *p*-series, Basic comparison test, Limit comparison test with applications, D'Alembert's ratio test and Cauchy's *n*th root test.
[3] Chapter 8 (Section 8.2 up to 8.2.19).

Weeks 13 and 14: Alternating series, Leibniz test, Absolute and conditional convergence.
[2] Chapter 6 (Section 6.2).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1. & 2.	Understand many properties of the real line ℝ including, completeness and Archimedean properties.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be	• Presentations and participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
3.	Learn to define sequences in terms of functions from ℕ to a subset of ℝ. Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.		

4.	Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.	encouraged to give short presentations. (v) Illustrate the concepts through CAS.	

Keywords: Archimedean property, Absolute and conditional convergence of series, Bolzano–Weierstrass theorem, Cauchy sequence, Convergent sequence, Leibniz test, Limit of a sequence, Nested intervals property, Open and closed sets in ℝ.

BMATH204: Differential Equations

Total Marks: 150 (Theory: 75, Internal Assessment: 25 and Practical: 50)
Workload: 4 Lectures, 4 Practicals (per week) **Credits:** 6 (4+2)
Duration: 14 Weeks (56 Hrs. Theory + 56 Hrs. Practical) **Examination:** 3 Hrs.

Course Objectives: The main objective of this course is to introduce the students to the exciting world of differential equations, mathematical modeling and their applications.

Course Learning Outcomes: The course will enable the students to:

i) Learn basics of differential equations and mathematical modeling.
ii) Formulate differential equations for various mathematical models.
iii) Solve first order non-linear differential equations and linear differential equations of higher order using various techniques.
iv) Apply these techniques to solve and analyze various mathematical models.

Unit 1: Differential Equations and Mathematical Modeling
Differential equations and mathematical models, Order and degree of a differential equation, Exact differential equations and integrating factors of first order differential equations, Reducible second order differential equations, Applications of first order differential equations to acceleration-velocity model, Growth and decay model.

Unit 2: Population Growth Models
Introduction to compartmental models, Lake pollution model (with case study of Lake Burley Griffin), Drug assimilation into the blood (case of a single cold pill, case of a course of cold pills, case study of alcohol in the bloodstream), Exponential growth of population, Limited growth of population, Limited growth with harvesting.

Unit 3: Second and Higher Order Differential Equations
General solution of homogeneous equation of second order, Principle of superposition for a homogeneous equation; Wronskian, its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, Method of undetermined coefficients, Method of variation of parameters, Applications of second order differential equations to mechanical vibrations.

Unit 4: Analysis of Mathematical Models
Interacting population models, Epidemic model of influenza and its analysis, Predator-prey model and its analysis, Equilibrium points, Interpretation of the phase plane, Battle model and its analysis.

References:

1. Barnes, Belinda & Fulford, Glenn R. (2015). *Mathematical Modelling with Case Studies, Using* Maple *and* MATLAB (3rd ed.). CRC Press, Taylor & Francis Group.
2. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). *Differential Equation and Boundary Value Problems*: *Computing and Modeling* (5th ed.). Pearson Education.
3. Ross, Shepley L. (2004). *Differential Equations* (3rd ed.). John Wiley & Sons. India

Additional Reading:

i. Ross, Clay C. (2004). *Differential Equations*: *An Introduction with Mathematica*® (2nd ed.). Springer.

Practical / Lab work to be performed in a Computer Lab:

Modeling of the following problems using Mathematica /MATLAB/Maple/Maxima/Scilab etc.

1. Plotting of second and third order respective solution family of differential equation.
2. Growth and decay model (exponential case only).
3. (i) Lake pollution model (with constant/seasonal flow and pollution concentration).
   (ii) Case of single cold pill and a course of cold pills.
   (iii) Limited growth of population (with and without harvesting).
4. (i) Predatory-prey model (basic Volterra model, with density dependence, effect of DDT, two prey one predator).
   (ii) Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).
   (iii) Battle model (basic battle model, jungle warfare, long range weapons).
5. Plotting of recursive sequences, and study of the convergence.
6. Find a value $m \in \mathbb{N}$ that will make the following inequality holds for all $n > m$:
   $(i)\ \left|\sqrt[n]{0.5} - 1\right| < 10^{-3}$, $\quad (ii)\ \left|\sqrt[n]{n} - 1\right| < 10^{-3}$,
   $(iii)\ (0.9)^n < 10^{-3}$, $\quad (iv)\ \frac{2^n}{n!} < 10^{-7}$, etc.
7. Verify the Bolzano–Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
8. Study the convergence/divergence of infinite series of real numbers by plotting their sequences of partial sum.
9. Cauchy's root test by plotting *n*th roots.
10. D'Alembert's ratio test by plotting the ratio of *n*th and (*n*+1)th term of the given series of positive terms.
11. For the following sequences $\langle a_n \rangle$, given $\varepsilon = \frac{1}{2^k}, p = 10^j, k = 0,1,2, \dots; j = 1,2,3, \dots$
    Find $m \in \mathbb{N}$ such that
    $(i)\ |a_{m+p} - a_m| < \varepsilon, \quad (ii)\ |a_{2m+p} - a_{2m}| < \varepsilon,$
    where a_n is given as:
    $$(a)\ \frac{n+1}{n}, \quad (b)\ \frac{1}{n}, \quad (c)\ 1 - \frac{1}{2} + \frac{1}{3} - \cdots + \frac{(-1)^{n-1}}{n}$$
    $$(d)\ \frac{(-1)^n}{n}, \quad (e)\ 2^{-n}n^2, \quad (f)\ 1 + \frac{1}{2!} + \cdots + \frac{1}{n!}.$$
12. For the following series $\sum a_n$, calculate
    $(i)\ \left|\frac{a_{n+1}}{a_n}\right|, \quad (ii)\ |a_n|^{\frac{1}{n}}$, for $n = 10^j, j = 1,2,3, \dots,$
    and identify the convergent series, where a_n is given as:
    $$(a)\left(\frac{1}{n}\right)^{1/n}, \quad (b)\frac{1}{n}, \quad (c)\ \frac{1}{n^2}, \quad (d)\left(1 + \frac{1}{\sqrt{n}}\right)^{-n^{3/2}},$$
    $$(e)\ \frac{n!}{n^n}, \quad (f)\ \frac{n^3 + 5}{3^n + 2}, \quad (g)\ \frac{1}{n^2 + n}, \quad (\square)\frac{1}{\sqrt{n+1}},$$
    $$(i) \cos n, \quad (j)\frac{1}{n \log n}, \quad (k)\frac{1}{n(\log n)^2}.$$

Teaching Plan (Theory of BMATH204: Differential Equations):

Weeks 1 and 2: Differential equations and mathematical models, Order and degree of a differential equation, Exact differential equations and integrating factors of first order differential equations, Reducible second order differential equations.

[2] Chapter 1 (Sections 1.1 and 1.6).
[3] Chapter 2.

Week 3: Application of first order differential equations to acceleration-velocity model, Growth and decay model.

[2] Chapter 1 (Section 1.4, Pages 35 to 38), and Chapter 2 (Section 2.3).
[3] Chapter 3 (Section 3.3, A and B with Examples 3.8, 3.9).

Week 4: Introduction to compartmental models, Lake pollution model (with case study of Lake Burley Griffin).

[1] Chapter 2 (Sections 2.1, 2.5 and 2.6).

Week 5: Drug assimilation into the blood (case of a single cold pill, case of a course of cold pills, Case study of alcohol in the bloodstream).

[1] Chapter 2 (Sections 2.7 and 2.8).

Week 6: Exponential growth of population, Density dependent growth, Limited growth with harvesting.

[1] Chapter 3 (Sections 3.1 to 3.3).

Weeks 7 to 9: General solution of homogeneous equation of second order, Principle of superposition for a homogeneous equation; Wronskian, its properties and applications; Linear homogeneous and non-homogeneous equations of higher order with constant coefficients; Euler’s equation.

[2] Chapter 3 (Sections 3.1 to 3.3).

Weeks 10 and 11: Method of undetermined coefficients, Method of variation of parameters; Applications of second order differential equations to mechanical vibrations.

[2] Chapter 3 (Sections 3.4 (Pages 172 to 177) and 3.5).

Weeks 12 to 14: Interacting population models, Epidemic model of influenza and its analysis, Predator-prey model and its analysis, Equilibrium points, Interpretation of the phase plane, Battle model and its analysis.

[1] Chapter 5 (Sections 5.1, 5.2, 5.4 and 5.9), and Chapter 6 (Sections 6.1 to 6.4).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Learn basics of differential equations and mathematical modeling.	(i) Each topic to be explained with examples and illustrated on computers using Mathematica /MATLAB /Maple/Maxima/Scilab. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be encouraged to give short presentations.	• Presentations and participation in discussions. • Assignments and class tests. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2.	Formulate differential equations for various mathematical models.		
3.	Solve first order non-linear differential equations and linear differential equations of higher order using various techniques.		
4.	Apply these techniques to solve and analyze various mathematical models.		

Keywords: Battle model, Epidemic model, Euler’s equation, Exact differential equation, Integrating factor, Lake pollution model, Mechanical vibrations, Phase plane, Predator-prey model, Wronskian and its properties.

Semester-III

BMATH305: Theory of Real Functions

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: It is a basic course on the study of real valued functions that would develop an analytical ability to have a more matured perspective of the key concepts of calculus, namely, limits, continuity, differentiability and their applications.

Course Learning Outcomes: This course will enable the students to:

i) Have a rigorous understanding of the concept of limit of a function.
ii) Learn about continuity and uniform continuity of functions defined on intervals.
iii) Understand geometrical properties of continuous functions on closed and bounded intervals.
iv) Learn extensively about the concept of differentiability using limits, leading to a better understanding for applications.
v) Know about applications of mean value theorems and Taylor's theorem.

Unit 1: Limits of Functions
Limits of functions ($\varepsilon-\delta$ approach), Sequential criterion for limits, Divergence criteria, Limit theorems, One-sided limits, Infinite limits and limits at infinity.

Unit 2: Continuous Functions and their Properties
Continuous functions, Sequential criterion for continuity and discontinuity, Algebra of continuous functions, Properties of continuous functions on closed and bounded intervals; Uniform continuity, Non-uniform continuity criteria, Uniform continuity theorem.

Unit 3: Derivability and its Applications
Differentiability of a function, Algebra of differentiable functions, Carathéodory's theorem, Chain rule; Relative extrema, Interior extremum theorem, Rolle's theorem, Mean-value theorem and applications, Intermediate value property of derivatives, Darboux's theorem.

Unit 4: Taylor's Theorem and its Applications
Taylor polynomial, Taylor's theorem with Lagrange form of remainder, Application of Taylor's theorem in error estimation; Relative extrema, and to establish a criterion for convexity; Taylor's series expansions of $e^x, \sin x$ and $\cos x$.

Reference:

1. Bartle, Robert G., & Sherbert, Donald R. (2015). *Introduction to Real Analysis* (4th ed.). Wiley India Edition. New Delhi.

Additional Readings:

i. Ghorpade, Sudhir R. & Limaye, B. V. (2006). *A Course in Calculus and Real Analysis*. Undergraduate Texts in Mathematics, Springer (SIE). First Indian reprint.
ii. Mattuck, Arthur. (1999). *Introduction to Analysis*, Prentice Hall.

iii. Ross, Kenneth A. (2013). *Elementary Analysis*: *The Theory of Calculus* (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian Reprint.

Teaching Plan (BMATH305: Theory of Real Functions):

Week 1: Definition of the limit, Sequential criterion for limits, Criterion for non-existence of limit.
[1] Chapter 4 (Section 4.1).

Week 2: Algebra of limits of functions with illustrations and examples, Squeeze theorem.
[1] Chapter 4 (Section 4.2).

Week 3: Definition and illustration of the concepts of one-sided limits, Infinite limits and limits at infinity.
[1] Chapter 4 (Section 4.3).

Weeks 4 and 5: Definitions of continuity at a point and on a set, Sequential criterion for continuity, Algebra of continuous functions, Composition of continuous functions.
[1] Sections 5.1 and 5.2.

Weeks 6 and 7: Various properties of continuous functions defined on an interval, viz., Boundedness theorem, Maximum-minimum theorem, Statement of the location of roots theorem, Intermediate value theorem and the preservation of intervals theorem.
[1] Chapter 5 (Section 5.3).

Week 8: Definition of uniform continuity, Illustration of non-uniform continuity criteria, Uniform continuity theorem.
[1] Chapter 5 [Section 5.4 (5.4.1 to 5.4.3)].

Weeks 9 and 10: Differentiability of a function, Algebra of differentiable functions, Carathéodory's theorem and chain rule.
[1] Chapter 6 [Section 6.1 (6.1.1 to 6.1.7)].

Weeks 11 and 12: Relative extrema, Interior extremum theorem, Mean value theorem and its applications, Intermediate value property of derivatives - Darboux's theorem.
[1] Section 6.2.

Weeks 13 and 14: Taylor polynomial, Taylor's theorem and its applications, Taylor's series expansions of $e^x, \sin x$ and $\cos x$.
[1] Chapter 6 (Sections 6.4.1 to 6.4.6), and Chapter 9 (Example 9.4.14, Page 286).

Facilitating the Achievement of Course Learning Outcomes

<table>
<tr><th>Unit No.</th><th>Course Learning Outcomes</th><th>Teaching and Learning Activity</th><th>Assessment Tasks</th></tr>
<tr><td>1.</td><td>Have a rigorous understanding of the concept of limit of a function.</td><td rowspan="4">(i) Each topic to be explained with examples.
(ii) Students to be involved in discussions and encouraged to ask questions.
(iii) Students to be given homework/ assignments.
(iv) Students to be encouraged to give short presentations.
(v) Illustrate the concepts through CAS.</td><td rowspan="4">• Presentations and participation in discussions.
• Assignments and class tests.
• Mid-term examinations.
• End-term examinations.</td></tr>
<tr><td>2.</td><td>Learn about continuity and uniform continuity of functions defined on intervals.
Understand geometrical properties of continuous functions on closed and bounded intervals.</td></tr>
<tr><td>3.</td><td>Learn extensively about the concept of differentiability using limits, leading to a better understanding for applications.</td></tr>
<tr><td>4.</td><td>Know about applications of mean value theorems and Taylor's theorem.</td></tr>
</table>

Keywords: Continuity, Convexity, Differentiability, Limit, Relative extrema, Rolle's theorem, Taylor's theorem, Uniform continuity.

BMATH306: Group Theory-I

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: The objective of the course is to introduce the fundamental theory of groups and their homomorphisms. Symmetric groups and group of symmetries are also studied in detail. Fermat's Little theorem as a consequence of the Lagrange's theorem on finite groups.

Course Learning Outcomes: The course will enable the students to:

i) Recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc.
ii) Link the fundamental concepts of groups and symmetrical figures.
iii) Analyze the subgroups of cyclic groups and classify subgroups of cyclic groups.
iv) Explain the significance of the notion of cosets, normal subgroups and factor groups.
v) Learn about Lagrange's theorem and Fermat's Little theorem.
vi) Know about group homomorphisms and group isomorphisms.

Unit 1: Groups and its Elementary Properties
Symmetries of a square, Dihedral groups, Definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), Elementary properties of groups.

Unit 2: Subgroups and Cyclic Groups
Subgroups and examples of subgroups, Centralizer, Normalizer, Center of a group, Product of two subgroups; Properties of cyclic groups, Classification of subgroups of cyclic groups.

Unit 3: Permutation Groups and Lagrange's Theorem
Cycle notation for permutations, Properties of permutations, Even and odd permutations, Alternating groups; Properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem; Normal subgroups, Factor groups, Cauchy's theorem for finite abelian groups.

Unit 4: Group Homomorphisms
Group homomorphisms, Properties of homomorphisms, Group isomorphisms, Cayley's theorem, Properties of isomorphisms, First, Second and Third isomorphism theorems for groups.

Reference:
1. Gallian, Joseph. A. (2013). *Contemporary Abstract Algebra* (8th ed.). Cengage Learning India Private Limited, Delhi. Fourth impression, 2015.

Additional Reading:
i. Rotman, Joseph J. (1995). *An Introduction to The Theory of Groups* (4th ed.). Springer-Verlag, New York.

Teaching Plan (BMATH306: Group Theory-I):

Week 1: Symmetries of a square, Dihedral groups, Definition and examples of groups including permutation groups and quaternion groups (illustration through matrices).
[1] Chapter 1.

Week 2: Definition and examples of groups, Elementary properties of groups.
[1] Chapter 2.

Week 3: Subgroups and examples of subgroups, Centralizer, Normalizer, Center of a Group, Product of two subgroups.
[1] Chapter 3.

Weeks 4 and 5: Properties of cyclic groups. Classification of subgroups of cyclic groups.
[1] Chapter 4

Weeks 6 and 7: Cycle notation for permutations, Properties of permutations, Even and odd permutations, Alternating group.
[1] Chapter 5 (up to Page 110).

Weeks 8 and 9: Properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.
[1] Chapter 7 (up to Example 6, Page 150).

Week 10: Normal subgroups, Factor groups, Cauchy's theorem for finite abelian groups.
[1] Chapters 9 (Theorem 9.1, 9.2, 9.3 and 9.5, and Examples 1 to 12).

Weeks 11 and 12: Group homomorphisms, Properties of homomorphisms, Group isomorphisms, Cayley's theorem.
[1] Chapter 10 (Theorems 10.1 and 10.2, Examples 1 to 11).
[1] Chapter 6 (Theorem 6.1, and Examples 1 to 8).

Weeks 13 and 14: Properties of isomorphisms, First, Second and Third isomorphism theorems.
[1] Chapter 6 (Theorems 6.2 and 6.3), Chapter 10 (Theorems 10.3, 10.4, Examples 12 to 14, and Exercises 41 and 42 for second and third isomorphism theorems for groups).

Facilitating the Achievement of Course Learning Outcomes

<table>
<tr><th>Unit No.</th><th>Course Learning Outcomes</th><th>Teaching and Learning Activity</th><th>Assessment Tasks</th></tr>
<tr><td>1.</td><td>Recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc.
Link the fundamental concepts of groups and symmetrical figures.</td><td rowspan="4">(i) Each topic to be explained with examples.
(ii) Students to be involved in discussions and encouraged to ask questions.
(iii) Students to be given homework/assignments.
(iv) Students to be encouraged to give short presentations.</td><td rowspan="4">• Presentations and participation in discussions.
• Assignments and class tests.
• Mid-term examinations.
• End-term examinations.</td></tr>
<tr><td>2.</td><td>Analyze the subgroups of cyclic groups and classify subgroups of cyclic groups.</td></tr>
<tr><td>3.</td><td>Explain the significance of the notion of cosets, normal subgroups and factor groups.
Learn about Lagrange's theorem and Fermat's Little theorem.</td></tr>
<tr><td>4.</td><td>Know about group homomorphisms and group isomorphisms.</td></tr>
</table>

Keywords: Cauchy's theorem for finite Abelian groups, Cayley's theorem, Centralizer, Cyclic group, Dihedral group, Group homomorphism, Lagrange's theorem, Normalizer, Permutations.

BMATH307: Multivariate Calculus

Total Marks: 150 (Theory: 75, Internal Assessment: 25 and Practical: 50)
Workload: 4 Lectures, 4 Practicals (per week) **Credits:** 6 (4+2)
Duration: 14 Weeks (56 Hrs. Theory + 56 Hrs. Practical) **Examination:** 3 Hrs.

Course Objectives: To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables. Also, the emphasis will be on the use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding. This course will facilitate to become aware of applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.

Course Learning Outcomes: This course will enable the students to:

i) Learn the conceptual variations when advancing in calculus from one variable to multivariable discussion.
ii) Understand the maximization and minimization of multivariable functions subject to the given constraints on variables.
iii) Learn about inter-relationship amongst the line integral, double and triple integral formulations.
iv) Familiarize with Green's, Stokes' and Gauss divergence theorems.

Unit 1: Calculus of Functions of Several Variables
Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Higher order partial derivative, Tangent planes, Total differential and differentiability, Chain rule, Directional derivatives, The gradient, Maximal and normal property of the gradient, Tangent planes and normal lines.

Unit 2: Extrema of Functions of Two Variables and Properties of Vector Field
Extrema of functions of two variables, Method of Lagrange multipliers, Constrained optimization problems; Definition of vector field, Divergence and curl.

Unit 3: Double and Triple Integrals
Double integration over rectangular and nonrectangular regions, Double integrals in polar co-ordinates, Triple integral over a parallelopiped and solid regions, Volume by triple integrals, Triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals.

Unit 4: Green's, Stokes' and Gauss Divergence Theorem
Line integrals, Applications of line integrals**:** Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral, Surface integrals, Stokes' theorem, Gauss divergence theorem.

Reference:

1. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). *Calculus* (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.

Additional Reading:

i. Marsden, J. E., Tromba, A., & Weinstein, A. (2004). *Basic Multivariable Calculus*. Springer (SIE). First Indian Reprint.

Practical / Lab work to be performed in Computer Lab.

List of practicals to be done using Mathematica / MATLAB / Maple/Maxima/Scilab, etc.

1. Let $f(x)$ be any function and L be any real number. For given a and $\varepsilon > 0$ find a $\delta > 0$ such that for all x satisfying $0 < |x - a| < \delta$, the inequality $0 < |f(x) - l| < \varepsilon$ holds. For example:
   (i) $f(x) = x + 1,\ L = 5, a = 4, \varepsilon = 0.01$.
   (ii) $f(x) = \sqrt{x+1}, L = 1, a = 4, \varepsilon = 0.1$.
   (iii) $f(x) = x^2, L = 4, a = -2, \varepsilon = 0.5$.
   (iv) $f(x) = \frac{1}{x}, L = -1, a = -1, \varepsilon = 0.1$.
2. Discuss the limit of the following functions when x tends to 0:
$$\pm\frac{1}{x}, \sin\left(\frac{1}{x}\right), \cos\left(\frac{1}{x}\right), x\sin\left(\frac{1}{x}\right), x\cos\left(\frac{1}{x}\right),\ x^2\sin\left(\frac{1}{x}\right),,$$
$$\frac{1}{x^n}\ (n \in \mathbb{N}), [x] \text{ greatest integer function, } \frac{1}{x}\sin\left(\frac{1}{x}\right).$$
3. Discuss the limit of the following functions when x tends to infinity:
$$e^{\pm\frac{1}{x}}, \sin\left(\frac{1}{x}\right),\ \frac{1}{x}e^{\pm x},\ \frac{x}{x+1},\ x^2\sin\left(\frac{1}{x}\right),\ \frac{ax+b}{cx^2+dx+e}\ (a \neq 0, c \neq 0).$$
4. Discuss the continuity of the functions at $x = 0$ in the Practical 2.
5. Illustrate the geometric meaning of Rolle's theorem of the following functions on the given interval:
   (i) $x^3 - 4x$ on [–2, 2]; (ii) $(x-3)^4(x-5)^3$ on [3, 5] etc.
6. Illustrate the geometric meaning of Lagrange's mean value theorem of the following functions on the given interval:
   (i) $\log x$ on [1/2, 2]; (ii) $x(x-1)(x-2)$ on [0, 1/2]; (iii) $2x^2 - 7x + 10$ on [2, 5] etc.
7. Draw the following surfaces and find level curves at the given heights:
   (i) $f(x,y) = 10 - x^2 - y^2; z = 1, z = 6, z = 9$.
   (ii) $f(x,y) = x^2 + y^2; z = 1, z = 6, z = 9$.
   (iii) $f(x,y) = x^3 - y; z = 1, z = 6$.
   (iv) $f(x,y) = x^2 + \frac{y^2}{4}; z = 1, z = 5, z = 8$.
   (v) $f(x,y) = 4x^2 + y^2; z = 0, z = 6, z = 9$.
8. Draw the following surfaces and discuss whether limit exits or not as (x,y) approaches to the given points. Find the limit, if it exists:
   (i) $f(x,y) = \frac{x+y}{x-y}; (x,y) \to (0,0)$ and $(x,y) \to (1,3)$.
   (ii) $f(x,y) = \frac{x-y}{\sqrt{x^2+y^2}}; (x,y) \to (0,0)$ and $(x,y) \to (2,1)$.
   (iii) $f(x,y) = (x+y)e^{xy}; (x,y) \to (1,1)$ and $(x,y) \to (1,0)$.
   (iv) $f(x,y) = e^{xy}; (x,y) \to (0,0)$ and $(x,y) \to (1,0)$.
   (v) $f(x,y) = \frac{x+y^2}{x^2+y^2}; (x,y) \to (0,0)$.
   (vi) $f(x,y) = \frac{x^2-y^2}{x^2+y^2}; (x,y) \to (0,0)$ and $(x,y) \to (2,1)$.
9. Draw the tangent plane to the following surfaces at the given point:
   (i) $f(x,y) = \sqrt{x^2+y^2}$ at $(3,1,\sqrt{10})$.

(ii) $f(x, y) = 10 - x^2 - y^2$ at (2,2,2).
(iii) $x^2 + y^2 + z^2 = 9$ at (3,0,0).
(iii) $z = \tan^{-1}x$ at $\left(1, \sqrt{3}, \frac{\pi}{3}\right)$ and $(2,2,\frac{\pi}{4})$.
(iii) $z = \log|x + y^2|$ at $(-3, -2, 0)$.

10. Use an incremental approximation to estimate the following functions at the given point and compare it with calculated value:
(i) $f(x, y) = 3x^4 + 2y^4$ at $(1.01, 2.03)$.
(ii) $f(x, y) = x^5 - 2y^3$ at $(0.98, 1.03)$.
(iii) $f(x, y) = e^{xy}$ at $(1.01, 0.98)$.
11. Find critical points and identify relative maxima, relative minima or saddle points to the following surfaces, if it exists:
(i) $z = x^2 + y^2$; $(ii)\ z = 1 - x^2 - y^2$; $(iii)\ z = y^2 - x^2$; $(iv)\ z = x^2y^4$.
12. Draw the following regions D and check whether these regions are of Type I or Type II:
(i) $D = \{(x, y): 0 \le x \le 2, 1 \le y \le e^x\}$.
(ii) $D = \{(x, y): \log y \le x \le 2, 1 \le y \le e^2\}$.
(iii) $D = \{(x, y): 0 \le x \le 1, x^3 \le y \le 1\}$.
(iv) The region *D* bounded by $y = x^2 - 2$ and the line $y = x$.
(v) $D = \left\{(x, y): 0 \le x \le \frac{\pi}{4}, \sin x \le y \le \cos x\right\}$.

Teaching Plan (Theory of BMATH307: Multivariate Calculus):

Week 1: Definition of functions of several variables, Graphs of functions of two variables – Level curves and surfaces, Limits and continuity of functions of two variables.
[1] Sections 11.1 and 11.2.

Week 2: Partial differentiation, and partial derivative as slope and rate, Higher order partial derivatives. Tangent planes, incremental approximation, Total differential.
[1] Chapter 11 (Sections 11.3 and 11.4).

Week 3: Differentiability, Chain rule for one parameter, Two and three independent parameters.
[1] Chapter 11 (Sections 11.4 and 11.5).

Week 4: Directional derivatives, The gradient, Maximal and normal property of the gradient, Tangent and normal lines.
[1] Chapter 11 (Section 11.6).

Week 5: First and second partial derivative tests for relative extrema of functions of two variables, and absolute extrema of continuous functions.
[1] Chapter 11 [Section 11.7 (up to page 605)].

Week 6: Lagrange multipliers method for optimization problems with one constraint, Definition of vector field, Divergence and curl.
[1] Sections 11.8 (Pages 610-614)] and 13.1.

Week 7: Double integration over rectangular and nonrectangular regions.
[1] Sections 12.1 and 12.2.

Week 8: Double integrals in polar co-ordinates, and triple integral over a parallelopiped.
[1] Chapter 12 (Sections 12.3 and 12.4).

Week 9: Triple integral over solid regions, Volume by triple integrals, and triple integration in cylindrical coordinates.
[1] Chapter 12 (Sections 12.4 and 12.5).

Week 10: Triple integration in spherical coordinates, Change of variables in double and triple integrals.
[1] Chapter 12 (Sections 12.5 and 12.6).

Week 11: Line integrals and its properties, applications of line integrals: mass and work.
[1] Chapter 13 (Section 13.2).

Week 12: Fundamental theorem for line integrals, Conservative vector fields and path independence.
[1] Chapter 13 (Section 13.3).
Week 13: Green's theorem for simply connected region, Area as a line integral, Definition of surface integrals.
[1] Chapter 13 [Sections 13.4 (Pages 712 to 716), 13.5 (Pages 723 to 726)].
Week 14: Stokes' theorem and the divergence theorem.
[1] Chapter 13 [Sections 13.6 (Pages 733 to 737), 13.7 (Pages 742 to 745)].

Note. To improve the problem solving ability, for similar kind of examples based upon the above contents, the Additional Reading (i) may be consulted.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Learn the conceptual variations when advancing in calculus from one variable to multivariable discussion.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2.	Understand the maximization and minimization of multivariable functions subject to the given constraints on variables.		
3.	Learn about inter-relationship amongst the line integral, double and triple integral formulations.		
4.	Familiarize with Green's, Stokes' and Gauss divergence theorems.		

Keywords: Directional derivatives, Double integral, Gauss divergence theorem, Green's theorem, Lagrange's multipliers, Level curves, Stokes' theorem, Volume integral, Vector field.

Skill Enhancement Paper

SEC-1: LaTeX and HTML

Total Marks: 100 (Theory: 38, Internal Assessment: 12, and Practical: 50)
Workload: 2 Lectures, 4 Practicals (per week) **Credits:** 4 (2+2)
Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) **Examination:** 2 Hrs.

Course Objectives: The purpose of this course is to acquaint students with the latest typesetting skills, which shall enable them to prepare high quality typesetting, beamer presentation and webpages.

Course Learning Outcomes: After studying this course the student will be able to:
i) Create and typeset a LaTeX document.
ii) Typeset a mathematical document using LaTex.
iii) Learn about pictures and graphics in LaTex.
iv) Create beamer presentations.
v) Create web page using HTML.

Unit 1: Getting Started with LaTeX
Introduction to TeX and LaTeX, Typesetting a simple document, Adding basic information to a document, Environments, Footnotes, Sectioning and displayed material.

Unit 2: Mathematical Typesetting with LaTeX
Accents and symbols, Mathematical typesetting (elementary and advanced)**:** Subscript/ Superscript, Fractions, Roots, Ellipsis, Mathematical Symbols, Arrays, Delimiters, Multiline formulas, Spacing and changing style in math mode.

Unit 3: Graphics and Beamer Presentation in LaTeX
Graphics in LaTeX, Simple pictures using PSTricks, Plotting of functions, Beamer presentation.

Unit 4: HTML
HTML basics, Creating simple web pages, Images and links, Design of web pages.

References:
1. Bindner, Donald & Erickson, Martin. (2011). *A Student's Guide to the Study, Practice, and Tools of Modern Mathematics*. CRC Press, Taylor & Francis Group, LLC.
2. Lamport, Leslie (1994). *LaTeX*: *A Document Preparation System*, User's Guide and Reference Manual (2nd ed.). Pearson Education. Indian Reprint.

Additional Readings:
i. Dongen, M. R. C. van (2012). *LaTeX and Friends*. Springer-Verlag.
ii. Robbins, J. N. (2018). *Learning Web Design*: *A Beginner's Guide to HTML* (5th ed.). O'Reilly Media Inc.

Practical / Lab work to be performed in Computer Lab.

[1] Chapter 9 (Exercises 4 to 10), Chapter 10 (Exercises 1 to 4 and 6 to 9),
Chapter 11 (Exercises 1, 3, 4, and 5), and Chapter 15 (Exercises 5, 6 and 8 to 11).

Teaching Plan (Theory of SEC-1: LaTeX and HTML):

Weeks 1 to 3: Introduction to TeX and LaTeX, Typesetting a simple document, Adding basic information to a document, Environments, Footnotes, Sectioning and displayed material.

[1] Chapter 9 (9.1 to 9.5).
[2] Chapter 2 (2.1 to 2.5).

Weeks 4 to 6: Accents of symbols, Mathematical typesetting (elementary and advanced): Subscript/Superscript, Fractions, Roots, Ellipsis, Mathematical symbols, Arrays, Delimiters, Multiline formulas, Spacing and changing style in math mode.

[1] Chapter 9 (9.6 and 9.7).
[2] Chapter 3 (3.1 to 3.3).

Weeks 7 and 8: Graphics in LaTeX, Simple pictures using PSTricks, Plotting of functions.

[1] Chapter 9 (Section 9.8). Chapter 10 (10.1 to 10.3).
[2] Chapter 7 (7.1 and 7.2).

Weeks 9 and 10: Beamer presentation.

[1] Chapter 11 (Sections 11.1 to 11.4).

Weeks 11 and 12: HTML basics, Creating simple web pages.

[1] Chapter 15 (Sections 15.1 and 15.2).

Weeks 13 and 14: Adding images and links, Design of web pages.

[1] Chapter 15 (Sections 15.3 to 15.5).

Facilitating the Achievement of Course Learning Outcomes

<table>
<tr><th>Unit No.</th><th>Course Learning Outcomes</th><th>Teaching and Learning Activity</th><th>Assessment Tasks</th></tr>
<tr><td>1.</td><td>Create and typeset a LaTeX document.</td><td rowspan="4">(i) Each topic to be explained with illustrations on computers.
(ii) Students be given homework/ assignments.
(iii) Students be encouraged to create simple webpages.</td><td rowspan="4">• Presentations and class discussions.
• Assignments and class tests.
• Mid-term examinations.
• End-term examinations.</td></tr>
<tr><td>2.</td><td>Typeset a mathematical document using LaTex.</td></tr>
<tr><td>3.</td><td>Learn about pictures and graphics in LaTex.
Create beamer presentations.</td></tr>
<tr><td>4.</td><td>Create web page using HTML.</td></tr>
</table>

Keywords: LaTex, Mathematical typesetting, PSTricks, Beamer, HTML.

Semester-IV

BMATH408: Partial Differential Equations

Total Marks: 150 (Theory: 75, Internal Assessment: 25 and Practical: 50)
Workload: 4 Lectures, 4 Practicals (per week) **Credits:** 6 (4+2)
Duration: 14 Weeks (56 Hrs. Theory + 56 Hrs. Practical) **Examination:** 3 Hrs.

Course Objectives: The main objectives of this course are to teach students to form and solve partial differential equations and use them in solving some physical problems.

Course Learning Outcomes: The course will enable the students to:
- i) Formulate, classify and transform first order PDEs into canonical form.
- ii) Learn about method of characteristics and separation of variables to solve first order PDE's.
- iii) Classify and solve second order linear PDEs.
- iv) Learn about Cauchy problem for second order PDE and homogeneous and non-homogeneous wave equations.
- v) Apply the method of separation of variables for solving many well-known second order PDEs.

Unit 1: First Order PDE and Method of Characteristics
Introduction, Classification, Construction and geometrical interpretation of first order partial differential equations (PDE), Method of characteristic and general solution of first order PDE, Canonical form of first order PDE, Method of separation of variables for first order PDE.

Unit 2: Mathematical Models and Classification of Second Order Linear PDE
Gravitational potential, Conservation laws and Burger's equations, Classification of second order PDE, Reduction to canonical forms, Equations with constant coefficients, General solution.

Unit 3: The Cauchy Problem and Wave Equations
Mathematical modeling of vibrating string and vibrating membrane, Cauchy problem for second order PDE, Homogeneous wave equation, Initial boundary value problems, Non-homogeneous boundary conditions, Finite strings with fixed ends, Non-homogeneous wave equation, Goursat problem.

Unit 4: Method of Separation of Variables
Method of separation of variables for second order PDE, Vibrating string problem, Existence and uniqueness of solution of vibrating string problem, Heat conduction problem, Existence and uniqueness of solution of heat conduction problem, Non-homogeneous problem.

Reference:
1. Myint-U, Tyn & Debnath, Lokenath. (2007). *Linear Partial Differential Equation for Scientists and Engineers* (4th ed.). Springer, Third Indian Reprint, 2013.

Additional Readings:

i. Sneddon, I. N. (2006). *Elements of Partial Differential Equations*, Dover Publications. Indian Reprint.
ii. Stavroulakis, Ioannis P & Tersian, Stepan A. (2004). *Partial Differential Equations: An Introduction with Mathematica and* MAPLE (2nd ed.). World Scientific.

Practical / Lab work to be performed in a Computer Lab:

Modeling of the following similar problems using Mathematica/MATLAB/Maple/Maxima/Scilab etc.

1. Solution of Cauchy problem for first order PDE.
2. Plotting the characteristics for the first order PDE.
3. Plot the integral surfaces of a given first order PDE with initial data.
4. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$ for any two of the following associated conditions:
   (i) $u(x,0) = \phi(x), \quad u(x,0) = \psi(x), \; x \in \mathbb{R}, \; t > 0.$
   (ii) $u(x,0) = \phi(x), \; u_t(x,0) = \psi(x), \quad u(0,t) = 0, x > 0 \; t > 0.$
   (iii) $u(x,0) = \phi(x), \; u_t(x,0) = \psi(x), \; u_x(0,t) = 0, \; x > 0, \; t > 0.$
   (iv) $u(x,0) = \phi(x), \quad u(x,0) = \psi(x), \quad u(0,t) = 0, \; u(l,t) = 0, 0 < x < l, \; t > 0.$
5. Solution of one-dimensional heat equation $u_t = k\, u_{xx}$, for a homogeneous rod of length l.
   That is - solve the IBVP:
$$u_t = k\, u_{xx}, \quad 0 < x < l, \quad t > 0,$$
$$u(0,t) = 0, \quad u(l,t) = 0, \quad t \geq 0,$$
$$u(0,t) = f(x), \; 0 \leq x \leq l.$$
6. Solving systems of ordinary differential equations.
7. Draw the following sequence of functions on the given interval and discuss the pointwise convergence:
   (i) $f_n(x) = x^n$ for $x \in \mathbb{R}$, (ii) $f_n(x) = \frac{x}{n}$ for $x \in \mathbb{R}$,
   (iii) $f_n(x) = \frac{x^2+nx}{n}$ for $x \in \mathbb{R}$, (iv) $f_n(x) = \frac{\sin nx + n}{n}$ for $x \in \mathbb{R}$
   (v) $f_n(x) = \frac{x}{x+n}$ for $x \in \mathbb{R}$ $x \geq 0$, (vi) $f_n(x) = \frac{nx}{1+n^2x^2}$ for $x \in \mathbb{R}$
   (vii) $f_n(x) = \frac{nx}{1+nx}$ for $x \in \mathbb{R}, x \geq 0$, (viii) $f_n(x) = \frac{x^n}{1+x^n}$ for $x \in \mathbb{R}, x \geq 0$
8. Discuss the uniform convergence of sequence of functions (i) to (viii) given above in (7).

Teaching Plan (Theory of BMATH408: Partial Differential Equations):

Week 1: Introduction, Classification, Construction of first order partial differential equations (PDE).
[1] Chapter 2 (Sections 2.1 to 2.3).

Week 2: Method of characteristics and general solution of first order PDE.
[1] Chapter 2 (Sections 2.4 and 2.5).

Week 3: Canonical form of first order PDE, Method of separation of variables for first order PDE.
[1] Chapter 2 (Sections 2.6 and 2.7).

Week 4: The vibrating string, Vibrating membrane, Gravitational potential, Conservation laws.
[1] Chapter 3 (Sections 3.1 to 3.3, 3.5 and 3.6).

Weeks 5 and 6: Reduction to canonical forms, Equations with constant coefficients, General solution.
[1] Chapter 4 (Sections 4.1 to 4.5).

Weeks 7 and 8: The Cauchy problem for second order PDE, Homogeneous wave equation.
[1] Chapter 5 (Sections 5.1, 5.3 and 5.4).

Weeks 9 and 10: Initial boundary value problem, Non-homogeneous boundary conditions, Finite string with fixed ends, Non-homogeneous wave equation, Goursat problem.
[1] Chapter 5 (Sections 5.5 to 5. and 5.9).
Weeks 11 and 12: Method of separation of variables for second order PDE, Vibrating string problem.
[1] Chapter 7 (Sections 7.1 to 7.3).
Weeks 13 and 14: Existence (omit proof) and uniqueness of vibrating string problem. Heat conduction problem. Existence (omit proof) and uniqueness of the solution of heat conduction problem. Non-homogeneous problem.
[1] Chapter 7 (Sections 7.4 to 7.6 and 7.8).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Formulate, classify and transform first order PDEs into canonical form. Learn about method of characteristics and separation of variables to solve first order PDEs.	(i) Each topic to be explained with examples. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students to be given homework/ assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2.	Classify and solve second order linear PDEs.		
3.	Learn about Cauchy problem for second order PDE and homogeneous and non-homogeneous wave equations.		
4.	Apply the method of separation of variables for solving many well-known second order PDEs.		

Keywords: Cauchy problem, Characteristics, Conservation laws and Burger's equations, Heat equation, Vibrating membrane, Wave equation.

BMATH409: Riemann Integration & Series of Functions

Total Marks: 100 (Theory: 75 and Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: To understand the integration of bounded functions on a closed and bounded interval and its extension to the cases where either the interval of integration is infinite, or the integrand has infinite limits at a finite number of points on the interval of integration. The sequence and series of real valued functions, and an important class of series of functions (i.e., power series).

Course Learning Outcomes: The course will enable the students to:

i) Learn about some of the classes and properties of Riemann integrable functions, and the applications of the Fundamental theorems of integration.
ii) Know about improper integrals including, beta and gamma functions.
iii) Learn about Cauchy criterion for uniform convergence and Weierstrass M-test for uniform convergence.
iv) Know about the constraints for the inter-changeability of differentiability and integrability with infinite sum.
v) Approximate transcendental functions in terms of power series as well as, differentiation and integration of power series.

Unit 1: Riemann Integration
Definition of Riemann integration, Inequalities for upper and lower Darboux sums, Necessary and sufficient conditions for the Riemann integrability, Definition of Riemann integration by Riemann sum and equivalence of the two definitions, Riemann integrability of monotone functions and continuous functions, Properties of Riemann integrable functions, Definitions of piecewise continuous and piecewise monotone functions and their Riemann integrability, intermediate value theorem for integrals, Fundamental theorems (I and II) of calculus, and the integration by parts.

Unit 2: Improper Integral
Improper integrals of Type-I, Type-II and mixed type, Convergence of beta and gamma functions, and their properties.

Unit 3: Sequence and Series of Functions
Pointwise and uniform convergence of sequence of functions, Theorem on the continuity of the limit function of a sequence of functions, Theorems on the interchange of the limit and derivative, and the interchange of the limit and integrability of a sequence of functions. Pointwise and uniform convergence of series of functions, Theorems on the continuity, derivability and integrability of the sum function of a series of functions, Cauchy criterion and the Weierstrass M-test for uniform convergence.

Unit 4: Power Series
Definition of a power series, Radius of convergence, Absolute convergence (Cauchy–Hadamard theorem), Uniform convergence, Differentiation and integration of power series, Abel's theorem.

References:

1. Bartle, Robert G., & Sherbert, Donald R. (2015). *Introduction to Real Analysis* (4th ed.). Wiley India Edition. Delhi.
2. Denlinger, Charles G. (2011). *Elements of Real Analysis*. Jones & Bartlett (Student Edition). First Indian Edition. Reprinted 2015.
3. Ghorpade, Sudhir R. & Limaye, B. V. (2006). *A Course in Calculus and Real Analysis*. Undergraduate Texts in Mathematics, Springer (SIE). First Indian reprint.
4. Ross, Kenneth A. (2013). *Elementary Analysis*: *The Theory of Calculus* (2nd ed.). Undergraduate Texts in Mathematics, Springer.

Additional Reading:

i. Bilodeau, Gerald G., Thie, Paul R., & Keough, G. E. (2010). *An Introduction to Analysis* (2nd ed.). Jones & Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.

Teaching Plan (BMATH409: Riemann Integration & Series of Functions):

Week 1: Definition of Riemann integration, Inequalities for upper and lower Darboux sums.
[4] Chapter 6 [Section 32 (32.1 to 32.4)].

Week 2: Necessary and sufficient conditions for the Riemann integrability, Definition of Riemann integration by Riemann sum and equivalence of the two definitions.
[4] Chapter 6 [Section 32 (32.5 to 32.10)].

Week 3: Riemann integrability of monotone functions and continuous functions, Algebra and properties of Riemann integrable functions.
[4] Chapter 6 [Section 33 (33.1 to 33.6)].

Week 4: Definitions of piecewise continuous and piecewise monotone functions and their Riemann integrability, Intermediate value theorem for integrals.
[4] Chapter 6 [Section 33 (33.7 to 33.10)].

Week 5: First and second fundamental theorems of integral calculus, and the integration by parts.
[4] Chapter 6 [Section 34 (34.1 to 34.3)].

Week 6: Improper integrals of Type-I, Type-II and mixed type.
[2] Chapter 7 [Section 7.8 (7.8.1 to 7.8.18)].

Week 7: Convergence of beta and gamma functions, and their properties.
[3] Pages 405-408.

Week 8: Definitions and examples of pointwise and uniformly convergent sequence of functions.
[1] Chapter 8 [Section 8.1 (8.1.1 to 8.1.10)].

Week 9: Motivation for uniform convergence by giving examples, Theorem on the continuity of the limit function of a sequence of functions.
[1] Chapter 8 [Section 8.2 (8.2.1 to 8.2.2)].

Week 10: The statement of the theorem on the interchange of the limit function and derivative, and its illustration with the help of examples, The interchange of the limit function and integrability of a sequence of functions.
[1] Chapter 8 [Section 8.2 (Theorems 8.2.3 and 8.2.4)].

Week 11: Pointwise and uniform convergence of series of functions, Theorems on the continuity, derivability and integrability of the sum function of a series of functions.
[1] Chapter 9 [Section 9.4 (9.4.1 to 9.4.4)].

Week 12: Cauchy criterion for the uniform convergence of series of functions, and the Weierstrass M-test for uniform convergence.
[2] Chapter 9 [Section 9.4 (9.4.5 to 9.4.6)].

Week 13: Definition of a power series, Radius of convergence, Absolute and uniform convergence of a power series.
[4] Chapter 4 (Section 23).

Week 14: Differentiation and integration of power series, Statement of Abel's theorem and its illustration with the help of examples.
[4] Chapter 4 [Section 26 (26.1 to 26.6)].

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Learn about some of the classes and properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be encouraged to give short presentations.	• Presentations and participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Know about improper integrals including, beta and gamma functions.		
3.	Learn about Cauchy criterion for uniform convergence and Weierstrass M-test for uniform convergence. Know about the constraints for the inter-changeability of differentiability and integrability with infinite sum.		
4.	Approximate transcendental functions in terms of power series as well as, differentiation and integration of power series.		

Keywords: Beta function, Gamma function, Improper integral, Power series, Radius of convergence, Riemann integration, Uniform convergence, Weierstrass M-test.

BMATH410: Ring Theory & Linear Algebra-I

Total Marks: 100 (Theory: 75 and Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: The objective of this course is to introduce the fundamental theory of two objects, namely - rings and vector spaces, and their corresponding homomorphisms.

Course Learning Outcomes: The course will enable the students to:

i) Learn about the fundamental concept of rings, integral domains and fields.
ii) Know about ring homomorphisms and isomorphisms theorems of rings.
iii) Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.
iv) Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.

Unit 1: Introduction of Rings
Definition and examples of rings, Properties of rings, Subrings, Integral domains and fields, Characteristic of a ring, Ideals, Ideal generated by a subset of a ring, Factor rings, Operations on ideals, Prime and maximal ideals.

Unit 2: Ring Homomorphisms
Ring homomorphisms, Properties of ring homomorphisms, First, Second and Third Isomorphism theorems for rings, The Field of quotients.

Unit 3: Introduction of Vector Spaces
Vector spaces, Subspaces, Algebra of subspaces, Quotient spaces, Linear combination of vectors, Linear span, Linear independence, Basis and dimension, Dimension of subspaces.

Unit 4: Linear Transformations
Linear transformations, Null space, Range, Rank and nullity of a linear transformation, Matrix representation of a linear transformation, Algebra of linear transformations, Isomorphisms, Isomorphism theorems, Invertibility and the change of coordinate matrix.

References:

1. Gallian, Joseph. A. (2013). *Contemporary Abstract Algebra* (8th ed.). Cengage Learning India Private Limited. Delhi. Fourth impression, 2015.
2. Friedberg, Stephen H., Insel, Arnold J., & Spence, Lawrence E. (2003). *Linear Algebra* (4th ed.). Prentice-Hall of India Pvt. Ltd. New Delhi.

Additional Readings:

i. Dummit, David S., & Foote, Richard M. (2016). *Abstract Algebra* (3rd ed.). Student Edition. Wiley India.
ii. Herstein, I. N. (2006). *Topics in Algebra* (2nd ed.). Wiley Student Edition. India.
iii. Hoffman, Kenneth, & Kunze, Ray Alden (1978). *Linear Algebra* (2nd ed.). Prentice-Hall of India Pvt. Limited. Delhi. Pearson Education India Reprint, 2015.

Teaching Plan (BMATH410: Ring Theory & Linear Algebra-I):

Week 1: Definition and examples of rings, Properties of rings, Subrings.
[1] Chapter 12.

Week 2: Integral domains and fields, Characteristic of a ring.
[1] Chapter 13.

Week 3 and 4: Ideals, Ideal generated by a subset of a ring, Factor rings, Operations on ideals, Prime and maximal ideals.
[1] Chapter 14.

Week 5: Ring homomorphisms, Properties of ring homomorphisms.
[1] Chapter 15 (up to Theorem 15.2).

Week 6: First, Second and Third Isomorphism theorems for rings, The field of quotients.
[1] Chapter 15 (Theorems 15.3 to 15.6, Examples 10 to 12), and Exercises 3 and 4 on Page 347.

Week 7: Vector spaces, Subspaces, Algebra of subspaces.
[2] Chapter 1 (Sections 1.2 and 1.3).

Week 8: Linear combination of vectors, Linear span, Linear independence.
[2] Chapter 1 (Sections 1.4 and 1.5).

Weeks 9 and 10: Bases and dimension. Dimension of subspaces.
[2] Chapter 1 (Section 1.6).

Week 11: Linear transformations, Null space, Range, Rank and nullity of a linear transformation.
[2] Chapter 2 (Section 2.1).

Weeks 12 and 13: Matrix representation of a linear transformation, Algebra of linear transformations.
[2] Chapter 2 (Sections 2.2 and 2.3).

Week 14: Isomorphisms, Isomorphism theorems, Invertibility and the change of coordinate matrix.
[2] Chapter 2 (Sections 2.4 and 2.5).

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Learn about the fundamental concept of rings, integral domains and fields.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be encouraged to give short presentations.	• Presentations and participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Know about ring homomorphisms and isomorphisms theorems of rings.		
3.	Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.		
4.	Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.		

Keywords: Basis and dimension of a vector space, Characteristic of a ring, Integral domain, Isomorphism theorems for rings, Linear transformations, Prime and maximal ideals, Quotient field, Vector space.

Skill Enhancement Paper

SEC-2: Computer Algebra Systems and Related Software

Total Marks: 100 (Theory: 38, Internal Assessment: 12, and Practical: 50)
Workload: 2 Lectures, 4 Practicals (per week) **Credits:** 4 (2+2)
Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) **Examination**: 2 Hrs.

Course Objectives: This course aims at familiarizing students with the usage of computer algebra systems (/Mathematica/MATLAB/Maxima/Maple) and the statistical software **R**. The basic emphasis is on plotting and working with matrices using CAS. Data entry and summary commands will be studied in **R**. Graphical representation of data shall also be explored.

Course Learning Outcomes: This course will enable the students to:

i) Use of computer algebra systems (Mathematica/MATLAB/Maxima/Maple etc.) as a calculator, for plotting functions and animations
ii) Use of CAS for various applications of matrices such as solving system of equations and finding eigenvalues and eigenvectors.
iii) Understand the use of the statistical software **R** as calculator and learn to read and get data into **R.**
iv) Learn the use of **R** in summary calculation, pictorial representation of data and exploring relationship between data.
v) Analyze, test, and interpret technical arguments on the basis of geometry.

Unit 1: Introduction to CAS and Applications
Computer Algebra System (CAS), Use of a CAS as a calculator, Computing and plotting functions in 2D, Plotting functions of two variables using Plot3D and ContourPlot, Plotting parametric curves surfaces, Customizing plots, Animating plots, Producing tables of values, working with piecewise defined functions, Combining graphics.

Unit 2: Working with Matrices
Simple programming in a CAS, Working with matrices, Performing Gauss elimination, operations (transpose, determinant, inverse), Minors and cofactors, Working with large matrices, Solving system of linear equations, Rank and nullity of a matrix, Eigenvalue, eigenvector and diagonalization.

Unit 3: R - The Statistical Programming Language
R as a calculator, Explore data and relationships in **R.** Reading and getting data into **R:** Combine and scan commands, Types and structure of data items with their properties, Manipulating vectors, Data frames, Matrices and lists, Viewing objects within objects, Constructing data objects and conversions.

Unit 4: Data Analysis with R
Summary commands**:** Summary statistics for vectors, Data frames, Matrices and lists, Summary tables, Stem and leaf plot, Histograms, Plotting in **R:** Box-whisker plots, Scatter plots, Pairs plots, Line charts, Pie charts, Cleveland dot charts and bar charts, Copy and save graphics to other applications.

References:
1. Bindner, Donald & Erickson, Martin. (2011). *A Student's Guide to the Study, Practice, and Tools of Modern Mathematics*. CRC Press, Taylor & Francis Group, LLC.
2. Torrence, Bruce F., & Torrence, Eve A. (2009). *The Student's Introduction to Mathematica®: A Handbook for Precalculus, Calculus, and Linear Algebra* (2nd ed.). Cambridge University Press.
3. Gardener, M. (2012). *Beginning R: The Statistical Programming Language*, Wiley.

Additional Reading:
- i. Verzani, John (2014). *Using R for Introductory Statistics* (2nd ed.). CRC Press, Taylor & Francis Group.

Note: Theoretical and Practical demonstration should be carried out only in **one** of the CAS: Mathematica/MATLAB/Maxima/Scilab or any other.

Practical / Lab work to be performed in Computer Lab.

[1] Chapter 12 (Exercises 1 to 4 and 8 to 12), Chapter 14 (Exercises 1 to 3)
[2] Chapter 3 [Exercises 3.2(1 and 2), 3.3(1, 2 and 4), 3.4(1 and 2), 3.5(1 to 4), 3.6(2 and 3)].
[2] Chapter 6 (Exercises 6.2 and 6.3) and Chapter 7 [Exercises 7.1(1), 7.2, 7.3(2), 7.4(1) and 7.6].

Note: Relevant exercises of [3] Chapters 2 to 5 and 7 (The practical may be done on the database to be downloaded from http://data.gov.in/).

Teaching Plan (Theory of SEC-1: Computer Algebra Systems and Related Software):

Weeks 1 to 3: Computer Algebra System (CAS), Use of a CAS as a calculator, Computing and plotting functions in 2D, Producing tables of values, Working with piecewise defined functions, Combining graphics. Simple programming in a CAS.
[1] Chapter 12 (Sections 12.1 to 12.5).
[2] Chapter 1, and Chapter 3 (Sections 3.1 to 3.6 and 3.8).

Weeks 4 and 5: Plotting functions of two variables using Plot3D and contour plot, Plotting parametric curves surfaces, Customizing plots, Animating plots.
[2] Chapter 6 (Sections 6.2 and 6.3).

Weeks 6 to 8: Working with matrices, Performing Gauss elimination, Operations (Transpose, Determinant, Inverse), Minors and cofactors, Working with large matrices, Solving system of linear equations, Rank and nullity of a matrix, Eigenvalue, Eigenvector and diagonalization.
[2] Chapter 7 (Sections 7.1 to 7.8).

Weeks 9 to 11: R as a calculator, Explore data and relationships in **R.** Reading and getting data into **R:** Combine and scan commands, Types and structure of data items with their properties. Manipulating vectors, Data frames, Matrices and lists. Viewing objects within objects. Constructing data objects and conversions.
[1] Chapter 14 (Sections 14.1 to 14.4).
[3] Chapter 2, and Chapter 3.

Weeks 12 to 14: Summary commands**:** Summary statistics for vectors, Data frames, Matrices and lists. Summary tables. Stem and leaf plot, histograms. Plotting in **R:** Box-whisker plots, Scatter plots, Pairs plots, Line charts, Pie charts, Cleveland dot charts and Bar charts. Copy and save graphics to other applications.

[1] Chapter 14 (Section 14.7).
[3] Chapter 5 (up to Page 157), and Chapter 7.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Use of computer algebra systems (Mathematica/MATLAB/Maxima/Maple etc.) as a calculator, for plotting functions and animations	(i) Each topic to be explained with illustrations using CAS or **R**. (ii) Students to be given homework/ assignments. (iii) Students to be encouraged to do look for new applications.	• Presentations and class discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Use of CAS for various applications of matrices such as solving system of equations and finding eigenvalues and eigenvectors.		
3.	Understand the use of the statistical software **R** as calculator and learn to read and get data into **R.**		
4.	Learn the use of **R** in summary calculation, pictorial representation of data and exploring relationship between data. Analyze, test, and interpret technical arguments on the basis of geometry.		

Keywords: Plot3D, ContourPlot, Calculator, Summary commands, Histograms.

Semester-V

BMATH511: Metric Spaces

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: Up to this stage, students do study the concepts of analysis which evidently rely on the notion of distance. In this course, the objective is to develop the usual idea of distance into an abstract form on any set of objects, maintaining its inherent characteristics, and the resulting consequences.

Course Learning Outcomes: The course will enable the students to:

i) Learn various natural and abstract formulations of distance on the sets of usual or unusual entities. Become aware one such formulations leading to metric spaces.
ii) Analyse how a theory advances from a particular frame to a general frame.
iii) Appreciate the mathematical understanding of various geometrical concepts, viz. balls or connected sets etc. in an abstract setting.
iv) Know about Banach fixed point theorem, whose far-reaching consequences have resulted into an independent branch of study in analysis, known as fixed point theory.
v) Learn about the two important topological properties, namely connectedness and compactness of metric spaces.

Unit 1: Basic Concepts
Metric spaces**:** Definition and examples, Sequences in metric spaces, Cauchy sequences, Complete metric space.

Unit 2: Topology of Metric Spaces

Open and closed ball, Neighborhood, Open set, Interior of a set, Limit point of a set, Derived set, Closed set, Closure of a set, Diameter of a set, Cantor's theorem, Subspaces, Dense set.

Unit 3: Continuity & Uniform Continuity in Metric Spaces

Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphism, Contraction mapping, Banach fixed point theorem.

Unit 4: Connectedness and Compactness
Connectedness, Connected subsets of $\mathbb{R}$, Connectedness and continuous mappings, Compactness, Compactness and boundedness, Continuous functions on compact spaces.

Reference:

1. Shirali, Satish & Vasudeva, H. L. (2009). *Metric Spaces*, Springer, First Indian Print.

Additional Readings:

i. Kumaresan, S. (2014). *Topology of Metric Spaces* (2nd ed.). Narosa Publishing House. New Delhi.
ii. Simmons, George F. (2004). *Introduction to Topology and Modern Analysis*. McGraw-Hill Education. New Delhi.

Teaching Plan (BMATH511: Metric Spaces):

Week 1: Definition of metric space, Illustration using the usual metric on $\mathbb{R}$, Euclidean and max metric on $\mathbb{R}^2$, Euclidean and max metric on $\mathbb{R}^n$, Discrete metric, Sup metric on B(S) and C[a, b], Integral metric on C[a, b].
[1] Chapter 1 [Section 1.2 (1.2.1, 1.2.2 ((i), (ii), (iv), (v), (viii), (ix), (x)), 1.2.3 and 1.2.4 (i))]

Week 2: Sequences in metric space, Definition of limit of a sequence, Illustration through examples, Cauchy sequences.
[1] Chapter 1 [Section 1.3 (1.3.1, 1.3.2, 1.3.3 ((i), (iv)), 1.3.5) and Section 1.4 (1.4.1 to 1.4.4)]

Week 3: Definition of complete metric spaces, Illustration through examples.
[1] Chapter 1 [Section 1.4 (1.4.5 to 1.4.7, 1.4.12 to 1.4.14(ii))].

Week 4: Open and closed balls, Neighborhood, Open sets, Examples and basic results.
[1] Chapter 2 [Section 2.1 (2.1.1 to 2.1.11 (except 2.1.6(ii)))].

Week 5: Interior point, Interior of a set, Limit point, Derived set, Examples and basic results.
[1] Chapter 2 [Section 2.1 (2.1.12 to 2.1.20)].

Week 6: Closed set, Closure of a set, Examples and basic results.
[1] Chapter 2 [Section 2.1 (2.1.21 to 2.1.35)].

Week 7: Bounded set, Diameter of a set, Cantor's theorem.
[1] Chapter 2 [Section 2.1 (2.1.41 to 2.1.44)].

Week 8: Relativisation and subspaces, Dense sets.
[1] Chapter 2 [Section 2.2 (2.2.1 to 2.2.6), Section 2.3 (2.3.12 to 2.3.13(iv))].

Weeks 9 to 11: Continuous mappings, Sequential and other characterizations of continuity, Uniform continuity, Homeomorphism, Contraction mappings, Banach fixed point theorem.
[1] Chapter 3 [Section 3.1, Section 3.4 (3.4.1 to 3.4.8), Section 3.5 (3.5.1 to 3.5.7(iii)), and Section 3.7 (3.7.1 to 3.7.5)].

Weeks 12 to 14: Connectedness and compactness, Definitions and properties of connected and compact spaces.
[1] Chapter 4 [Section 4.1 (4.1.1 to 4.1.12)], and Chapter 5 [Section 5.1 (5.1.1 to 5.1.6), and Section 5.3 (5.3.1 to 5.3.10)].

Facilitating the Achievement of Course Learning Outcomes

<table>
<tr><th>Unit No.</th><th>Course Learning Outcomes</th><th>Teaching and Learning Activity</th><th>Assessment Tasks</th></tr>
<tr><td>1.</td><td>Learn various natural and abstract formulations of distance on the sets of usual or unusual entities. Become aware one such formulations leading to metric spaces. Analyse how a theory advances from a particular frame to a general frame.</td><td rowspan="4">(i) Each topic to be explained with examples.
(ii) Students to be involved in discussions and encouraged to ask questions.
(iii) Students to be given homework/assignment.
(iv) Students to be encouraged to give short presentations.
(v) Illustrate the concepts through CAS.</td><td rowspan="4">• Student presentations
• Participation in discussions.
• Assignments and class tests.
• Mid-term examinations.
• End-term examinations.</td></tr>
<tr><td>2.</td><td>Appreciate the mathematical understanding of various geometrical concepts, viz. balls or connected sets etc. in an abstract setting.</td></tr>
<tr><td>3.</td><td>Know about Banach fixed point theorem, whose far-reaching consequences resulted into an independent branch of study in analysis, known as fixed point theory.</td></tr>
<tr><td>4.</td><td>Learn about the two important topological properties, namely connectedness and compactness of metric spaces.</td></tr>
</table>

Keywords: Banach fixed point theorem, Cantor's theorem, Closure, Compactness, Connectedness, Contraction mapping, Interior, Open set.

BMATH512: Group Theory-II

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination**: 3 Hrs.

Course Objectives: The course will develop an in-depth understanding of one of the most important branch of the abstract algebra with applications to practical real-world problems. Classification of all finite abelian groups (up to isomorphism) can be done.

Course Learning Outcomes: The course shall enable students to:

i) Learn about automorphisms for constructing new groups from the given group.
ii) Learn about the fact that external direct product applies to data security and electric circuits.
iii) Understand fundamental theorem of finite abelian groups.
iv) Be familiar with group actions and conjugacy in S_n.
v) Understand Sylow theorems and their applications in checking nonsimplicity.

Unit 1: Automorphisms and Properties
Automorphism, inner automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups, Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups.

Unit 2: External and Internal Direct Products of Groups
External direct products of groups and its properties, The group of units modulo n as an external direct product, Applications to data security and electric circuits; Internal direct products, Classification of groups of order p^2, where p is a prime; Fundamental theorem of finite abelian groups and its isomorphism classes.

Unit 3: Group Action
Group actions and permutation representations; Stabilizers and kernels of group actions; Groups acting on themselves by left multiplication and consequences; Conjugacy in S_n.

Unit 4: Sylow Theorems and Applications
Conjugacy classes, Class equation, p-groups, Sylow theorems and consequences, Applications of Sylow theorems; Finite simple groups, Nonsimplicity tests; Generalized Cayley's theorem, Index theorem, Embedding theorem and applications. Simplicity of A_5.

References:

1. Dummit, David S., & Foote, Richard M. (2016). *Abstract Algebra* (3rd ed.). Student Edition. Wiley India.
2. Gallian, Joseph. A. (2013). *Contemporary Abstract Algebra* (8th ed.). Cengage Learning India Private Limited. Delhi. Fourth impression, 2015.

Additional Reading:

i. Rotman, Joseph J. (1995). *An Introduction to The Theory of Groups* (4th ed.). Springer-Verlag, New York.

Teaching Plan (BMATH512: Group Theory-II):

Week 1: Automorphism, Inner automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups.

[2] Chapter 6 (Pages 135 to 138).

Week 2: Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups.

[2] Exercises 1 to 4 on Page 181, and Exercises 62, 68 on Page 204.

[2] Chapter 9 (Theorem 9.4 and Example 17).

Week 3: External direct products of groups and its properties, The group of units modulo n as an external direct product, Applications to data security and electric circuits.

[2] Chapter 8.

Week 4: Internal direct products, Classification of groups of order p^2, where p is a prime.

[2] Chapter 9 (Section on internal direct products, Pages 195 to 200).

Week 5: Statement of the Fundamental theorem of finite abelian groups, The isomorphism classes of Abelian groups.

[2] Chapter 11.

Weeks 6 and 7: Group actions and permutation representations; Stabilizers and kernels of group actions.

[1] Chapter 1 (Section 1.7), Chapter 2 (Section 2.2) and Chapter 4 (Section 4.1, except cycle decompositions).

Weeks 8 and 9: Groups acting on themselves by left multiplication and consequences; Conjugacy in S_n.

[1] Chapter 4 [Section 4.2 and Section 4.3 (Pages 125-126)].

Week 10: Conjugacy classes, Class equation, p-groups.

[2] Chapter 24 (Pages 409 to 411).

Weeks 11 and 12: State three Sylow theorems and give their applications.

[2] Chapter 24 (Pages 412 to 421).

Weeks 13 and 14: Finite simple groups, Nonsimplicity tests; Generalized Cayley's theorem, Index theorem, Embedding theorem and applications; Simplicity of A_5.

[2] Chapter 25.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Learn about automorphisms for constructing new groups from the given group. Learn about the fact that external direct product applies to data security and electric circuits.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be encouraged to give short presentations.	• Presentations and participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Understand fundamental theorem of finite abelian groups.		
3.	Be familiar with group actions and conjugacy in S_n.		
4.	Understand Sylow theorems and their applications in checking nonsimplicity.		

Keywords: Automorphism, External direct products, Isomorphism classes, Group action, Class equation, Sylow theorems.

Discipline Specific Elective (DSE) Course -1 (including practicals)

Any *one* of the following (at least *two* shall be offered by the college):

DSE-1 (i): Numerical Analysis
DSE-1 (ii): Mathematical Modeling and Graph Theory
DSE-1 (iii): C++ Programming for Mathematics

DSE-1 (i): Numerical Analysis

Total Marks: 150 (Theory: 75 + Internal Assessment: 25 + Practical: 50)
Workload: 4 Lectures, 4 Periods practical (per week) **Credits:** 6 (4+2)
Duration: 14 Weeks (56 Hrs. Theory + 56 Hrs. practical) **Examination:** 3 Hrs.

Course Objectives: To comprehend various computational techniques to find approximate value for possible root(s) of non-algebraic equations, to find the approximate solutions of system of linear equations and ordinary differential equations. Also, the use of Computer Algebra System (CAS) by which the numerical problems can be solved both numerically and analytically, and to enhance the problem solving skills.

Course Learning Outcomes: The course will enable the students to:

i) Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.
ii) Know about methods to solve system of linear equations, such as Gauss–Jacobi, Gauss–Seidel and SOR methods.
iii) Interpolation techniques to compute the values for a tabulated function at points not in the table.
iv) Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.

Unit 1: Methods for Solving Algebraic and Transcendental Equations
Algorithms, Convergence, Bisection method, False position method, Fixed point iteration method, Newton's method and Secant method.

Unit 2:Techniques to Solve Linear Systems
Partial and scaled partial pivoting, LU decomposition and its applications, Iterative methods: Gauss–Jacobi, Gauss–Seidel and SOR methods.

Unit 3: Interpolation
Lagrange and Newton interpolation, Piecewise linear interpolation.

Unit 4: Numerical Differentiation and Integration
First and higher order approximation for first derivative, Approximation for second derivative, Richardson extrapolation method; Numerical integration by closed Newton–Cotes formulae**:** Trapezoidal rule, Simpson's rule and its error analysis; Euler’s method to solve ODE’s, Second order Runge–Kutta Methods**:** Modified Euler’s method, Heun’s method and optimal RK2 method.

Note: Emphasis is to be laid on the algorithms of the above numerical methods. Non programmable scientific calculator may be allowed in the University examination.

Reference:

1. Bradie, Brian. (2006). *A Friendly Introduction to Numerical Analysis*. Pearson Education, India. Dorling Kindersley (India) Pvt. Ltd. Third impression 2011.

Additional Readings:

i. Jain, M. K., Iyengar, S. R. K., & Jain, R. K. (2012). *Numerical Methods for Scientific and Engineering Computation*. (6th ed.). New Age International Publisher, India, 2016.
ii. Gerald, C. F., & Wheatley, P. O. (2008). *Applied Numerical Analysis* (7th ed.). Pearson Education. India.

Practical / Lab work to be performed in Computer Lab:

Use of computer algebra software (CAS), for example Mathematica/MATLAB/Maple/ Maxima/Scilab etc., for developing the following numerical programs:

1. Bisection method
2. Newton–Raphson method
3. Secant method
4. Regula–Falsi method
5. LU decomposition method
6. Gauss–Jacobi method
7. SOR method
8. Gauss–Seidel method
9. Lagrange interpolation
10. Newton interpolation
11. Trapezoidal rule
12. Simpson's rule
13. Euler's method
14. Second order Runge–Kutta methods.

Note: For any of the CAS: Mathematica /MATLAB/ Maple/Maxima/Scilab etc., data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

Teaching Plan (Theory of DSE-I (i): Numerical Analysis):

Week 1: Algorithms, Convergence, Order of convergence and examples.
[1] Chapter 1 (Sections 1.1 and 1.2).

Week 2: Bisection method, False position method and their convergence analysis, Stopping condition and algorithms.
[1] Chapter 2 (Sections 2.1 and 2.2).

Week 3: Fixed point iteration method, its order of convergence and stopping condition.
[1] Chapter 2 (Section 2.3).

Week 4: Newton's method, Secant method, their order of convergence and convergence analysis.
[1] Chapter 2 (Sections 2.4 and 2.5).

Week 5: Examples to understand partial and scaled partial pivoting. LU decomposition.
[1] Chapter 3 (Sections 3.2, and 3.5 up to Example 3.15).

Weeks 6 and 7: Application of LU decomposition to solve system of linear equations. Gauss–Jacobi method, Gauss–Seidel and SOR iterative methods to solve system of linear equations.
[1] Chapter 3 (Sections 3.5 and 3.8).

Week 8: Lagrange interpolation**:** Linear and higher order interpolation, and error in it.
[1] Chapter 5 (Section 5.1).

Weeks 9 and 10: Divided difference and Newton interpolation, Piecewise linear interpolation.
[1] Chapter 5 (Sections 5.3 and 5.5).

Weeks 11 and 12: First and higher order approximation for first derivative and error in the approximation. Second order forward, Backward and central difference approximations for second derivative, Richardson extrapolation method
[1] Chapter 6 (Sections 6.2 and 6.3).

Week 13: Numerical integration**:** Trapezoidal rule, Simpson's rule and its error analysis.
[1] Chapter 6 (Section 6.4).

Week 14: Euler's method to solve ODE's, Second order Runge–Kutta methods**:** Modified Euler's method, Heun's method and optimal RK2 method.
[1] Chapter 7 (Section 7.2 up to Page 562 and Section 7.4, Pages 582-585).

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.	(i) Each topic to be explained with illustrations. (ii) Students be encouraged to discover the relevant concepts. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2.	Know about methods to solve system of linear equations, such as Gauss–Jacobi, Gauss–Seidel and SOR methods.		
3.	Interpolation techniques to compute the values for a tabulated function at points not in the table.		
4.	Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.		

Keywords: Algorithm, Euler's method, Interpolation, Iterative methods, LU decomposition, Newton–Cotes formulae, Order of convergence, Order of a method, Partial pivoting.

DSE-1 (ii): Mathematical Modeling and Graph Theory

Total Marks: 150 (Theory: 75 + Internal Assessment: 25 + Practical: 50)
Workload: 4 Lectures, 4 Periods practical (per week) **Credits:** 6 (4+2)
Duration: 14 Weeks (56 Hrs. Theory + 56 Hrs. practical) **Examination:** 3 Hrs.

Course Objectives: The main objective of this course is to teach students how to model physical problems using differential equations and solve them. Also, the use of Computer Algebra Systems (CAS) by which the listed problems can be solved both numerically and analytically.

Course Learning Outcomes: The course will enable the students to:

i) Know about power series solution of a differential equation and learn about Legendre's and Bessel's equations.
ii) Use of Laplace transform and inverse transform for solving initial value problems.
iii) Learn about various models such as Monte Carlo simulation models, queuing models, and linear programming models.
iv) Understand the basics of graph theory and learn about social networks, Eulerian and Hamiltonian graphs, diagram tracing puzzles and knight's tour problem.

Unit 1: Power Series Solutions
Power series solution of a differential equation about an ordinary point, Solution about a regular singular point, The method of Frobenius, Legendre's and Bessel's equations.

Unit 2: Laplace Transforms
Laplace transform and inverse transform, Application to initial value problem up to second order.

Unit 3: Monte Carlo Simulation
Monte Carlo simulation modeling**:** Simulating deterministic behavior (area under a curve, volume under a surface); Generating random numbers**:** Middle square method, Linear congruence; Queuing models**:** Harbor system, Morning rush hour; Overview of optimization modeling; Linear programming model: Geometric solution, Algebraic solution, Simplex method, Sensitivity analysis.

Unit 4: Graph Theory
Graphs, Diagraphs, Networks and subgraphs, Vertex degree, Paths and cycles, Regular and bipartite graphs, Four cube problem, Social networks, Exploring and traveling, Eulerian and Hamiltonian graphs, Applications to dominoes, Diagram tracing puzzles, Knight's tour problem, Gray codes.

References:

1. Aldous, Joan M., & Wilson, Robin J. (2007). *Graphs and Applications*: *An Introductory Approach*. Springer. Indian Reprint.
2. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). *Differential Equations and Boundary Value Problems*: *Computing and Modeling* (5th ed.). Pearson.
3. Giordano, Frank R., Fox, William P., & Horton, Steven B. (2014). *A First Course in Mathematical Modeling* (5th ed.). Brooks/Cole, Cengage Learning.

Practical / Lab work to be performed in Computer Lab:

Modeling of the following problems using Mathematica/MATLAB/Maple/Maxima/Scilab etc.

1. Plotting of Legendre polynomial for n = 1 to 5 in the interval [0, 1]. Verifying graphically that all the roots of $P_n(x)$ lie in the interval [0, 1].
2. Automatic computation of coefficients in the series solution near ordinary points.
3. Plotting of the Bessel's function of first kind of order 0 to 3.
4. Automating the Frobenius series method.
5. (i) Random number generation and then use it for one of the following:
   - (a) Simulate area under a curve,
   - (b) Simulate volume under a surface.

   (ii) Programming of either one of the queuing model:
   - (a) Single server queue (e.g. Harbor system),
   - (b) Multiple server queue (e.g. Rush hour).

   (iii) Programming of the Simplex method for 2 / 3 variables.

Teaching Plan (Theory of DSE-l (ii): Mathematical Modeling and Graph Theory):

Weeks 1 and 3: Power series solution of a differential equation about an ordinary point, Solution about a regular singular point. Legendre's equation. The method of Frobenius.

[2] Chapter 8 (Sections 8.1 to 8.3).

Week 4: Bessel's equation. Bessel's function of first kind.

[2] Chapter 8 [Section 8.5 up to Equation (19), Page 551)].

Weeks 5 and 6: Laplace transform and inverse transform, Application to initial value problem up to second order.

[2] Chapter 7 (Sections 7.1 to 7.3).

Weeks 7 and 8: Monte Carlo simulation modeling**:** Simulating deterministic behavior (area under a curve, volume under a surface), Generating random numbers**:** Middle square method, Linear congruence. Queuing models**:** Harbor system, Morning rush hour.

[3] Chapter 5 (Sections 5.1 to 5.2, and 5.5).

Weeks 9 and 10: Overview of optimization modeling, Linear programming model: Geometric solution, Algebraic solution, Simplex method, Sensitivity analysis.

[3] Chapter 7.

Weeks 11 and 12: Graphs, Diagraphs, Networks and subgraphs, Vertex degree, Paths and cycles, Regular and bipartite graphs, Four cube problem, Social networks.

[1] Chapter 1 (Section 1.1), and Chapter 2.

Weeks 13 and 14: Overview of optimization modeling, Linear Programming Model: Geometric solution, Algebraic solution, Simplex method, Sensitivity analysis.

[1] Chapter 3.

Note: [1] Chapter 1 (Section 1.1), Chapter 2 (Sections 2.1 to 2.4), Chapter 3 (Sections 3.1 to 3.3) are to be reviewed only. This is in order to understand the models on Graph Theory.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Know about power series solution of a differential equation and learn about Legendre's and Bessel's equations.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant	• Presentations and class discussions. • Assignments and

2.	Use of Laplace transform and inverse transform for solving initial value problems.	concepts. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
3.	Learn about various models such as Monte Carlo simulation models, queuing models, and linear programming models.		
4.	Understand the basics of graph theory and learn about social networks, Eulerian and Hamiltonian graphs, diagram tracing puzzles and knight's tour problem.		

Keywords: Legendre's and Bessel's equations, Laplace transformm Monte Carlo simulation, Hamiltonian graphs.

DSE-1 (iii): C++ Programming for Mathematics

Total Marks: 150 (Theory: 75 + Internal Assessment: 25 + Practical: 50)
Workload: 4 Lectures, 4 Periods practical (per week) **Credits:** 6 (4+2)
Duration: 14 Weeks (56 Hrs. Theory + 56 Hrs. practical) **Examination:** 3 Hrs.

Course Objectives: This course introduces C++ programming in the idiom and context of mathematics and imparts a starting orientation using available mathematical libraries, and their applications.

Course Learning Outcomes: After completion of this paper, student will be able to:

i) Understand and apply the programming concepts of C++ which is important to mathematical investigation and problem solving.
ii) Learn about structured data-types in C++ and learn about applications in factorization of an integer and understanding Cartesian geometry and Pythagorean triples.
iii) Use of containers and templates in various applications in algebra.
iv) Use mathematical libraries for computational objectives.
v) Represent the outputs of programs visually in terms of well formatted text and plots.

Unit 1: C++ Essentials
Fundamentals of programming, Organization of logic flow in stored program model of computation, C++ as a general purpose programming language, Structure of a C++ program, Common compilers and IDE's, Basic data-types, Variables and literals in C++, Operators, Expressions, Evaluation precedence, and Type compatibility. Outline of program development in C++, Debugging and testing; Applications**:** Greatest common divisor, and Random number generation.

Unit 2: Working with Structured Data
Structured data-types in C++, Arrays and manipulating data in arrays with applications in factorization of an integer and finding Euler's totient; Objects and classes**:** Information hiding, Modularity, Constructors and Destructors, Methods and Polymorphism; Applications**:** Cartesian geometry using points (2 & 3-dimensional), and Pythagorean triples.

Unit 3: Working with Containers and Templates
Containers and Template Libraries**:** Sets, Iterators, Multisets, Vectors, Maps, Lists, Stacks and Queues; Applications**:** Basic set algebra, Modulo arithmetic, Permutations, and Polynomials.

Unit 4: Using Mathematical Libraries and Packages
Arbitrary precision arithmetic using the GMP package; Linear algebra**:** Two-dimensional arrays in C++ with applications in finding eigenvalues, eigenvectors, rank, nullity, and solving system of linear equations in matrices; Features of C++ for input/output and visualization**:** strings, streams, formatting method; Processing files in a batch, Command-line arguments, Visualization packages and their use in plots.

Reference:

1. Scheinerman, Edward (2006). *C++ for Mathematicians*: *An Introduction for Students and Professionals*. Chapman & Hall/CRC. Taylor & Francis Group, LLC.

Additional Readings:

i. Dale, Nell & Weems, Chip (2013). *Programming and Problem Solving with C++* (6th ed.). Comprehensive Edition. Jones & Bartlett Learning.
ii. Gottschling, Peter (2016). *Discovering Modern C++: An Intensive Course for Scientists, Engineers, and Programmers*. Addison-Wesley. Pearson Education, Inc.
iii. Josuttis, Nicolai M. (2012). *The C++ Standard Library: A Tutorial and Reference* (2nd ed.). Addison-Wesley. Pearson Education, Inc.
iv. Lippman, Stanley B. (2000). *Essential C++*. Addison-Wesley.
v. Stroustrup, Bjarne (2013). *The C++ Programming Language* (4th ed.). Addison-Wesley.

Practical / Lab work to be performed in Computer Lab:

A: Preparatory (Practical Sessions: 8 Hrs.)

1. Setting up of C++ programming environment on Linux/Windows/Mac-OS; gcc/g++/mingw/cc, Program-development methodology and use IDE's or other tools.
2. Demonstration of sample programs for
   (i) "Hello World"
   (ii) Sum of an arithmetic progression.
   (iii) Value of $\sin x$ using series expansion.
3. Finding/demonstrating:
   (i) Machine epsilon.
   (ii) Integer and float overflow/underflow.
   (iii) Iteration and selection based logic.
   (provide a list of 8-10 problems suitable to learners needs)

B: Evaluative:

Set-I: (Practical Sessions: 8 Hrs.)

1. Greatest common divisor (including Euclid's Method).
2. Random number generation (including a Monte Carlo Program).

Set-II: (Practical Sessions: 12 Hrs.)

1. Factorization of an integer, and Euler's totient.
2. Cartesian geometry using points (2 & 3-dimensional).
3. Pythagorean triples.

Set-III: (Practical Sessions: 16 Hrs.)

1. Basic set algebra.
2. Modulo arithmetic.
3. Permutations.
4. Polynomials.

Set-IV: (Practical Sessions: 12 Hrs.)

1. Arbitrary precision arithmetic using the GMP package.
2. Finding eigenvalues, eigenvectors, rank, nullity, and solving system of linear equations in matrices.
3. Plots (using the GNU plotutils package).

Note. Exception handling in lab-exercises (SET-I to IV), Comments/Documentation using Doxygen may be emphasized.

Teaching Plan (Theory of DSE-1 (iii) C++ Programming for Mathematics):

Week 1: Fundamentals of programming, Organization of logic flow in stored program model of computation, C++ as a general purpose programming language, Structure of a C++ program, Common compilers and IDE's, Basic data-types.

[1] Chapter 1, and Chapter 2 (Sections 2.1 to 2.3).

Week 2: Variables and literals in C++, Operators, Expressions, Evaluation precedence, and Type compatibility. Outline of program development in C++, Debugging and testing.

[1] Chapter 2 (Sections 2.4 to 2.9).

Weeks 3 and 4: Applications**:** Greatest common divisor, and Random number generation.

[1] Chapters 3 and 4.

Week 5: Structured data-types in C++, Arrays and manipulating data in arrays. Applications**:** Factorization of an integer, and Euler's totient.

[1] Chapter 5 (Sections 5.1 to 5.4).

Weeks 6 and 7: Objects and classes**:** Information hiding, Modularity, Constructors and destructors, Methods and polymorphism; Applications**:** Cartesian geometry using points (two and three dimensional), and Pythagorean triples.

[1] Chapters 6 and 7.

Weeks 8 and 9: Containers and template libraries**:** sets, iterators, multisets, vectors, maps, lists, stacks and queues with applications in basic set algebra.

[1] Sections 8.1 to 8.7 (8.7.1-8.7.3).

Weeks 10 and 11: Applications**:** modulo arithmetic, permutations, and polynomials.

[1] Chapter 9, Chapter 11 (Sections 11.1, and 11.2) and Chapter 12 (Sections 12.1 to 12.3).

Week 12: Arbitrary precision arithmetic using the GMP package; Linear algebra**:** Two-dimensional arrays in C++ with applications in finding eigenvalues, eigenvectors, rank, nullity, and solving system of linear equations in matrices.

[1] Chapter 13 [Sections 13.1, and 13.2 (13.2.1, 13.2.2)].

Weeks 13 and 14: Features of C++ for input/output & visualization**:** strings, streams, formatting methods, processing files in a batch, command-line arguments, visualization packages and plots.

[1] Chapter 14 [Sections 14.1 to 14.6, and 14.8 (14.8.1-14.8.3)].

Facilitating the Achievement of Course Learning Outcomes

<table>
<tr><th>Unit No.</th><th>Course Learning Outcomes</th><th>Teaching and Learning Activity</th><th>Assessment Tasks</th></tr>
<tr><td>1.</td><td>Understand and apply the programming concepts of C++ which is important to mathematical investigation and problem solving.</td><td rowspan="4">(i) Each topic to be explained with illustrations.
(ii) Students to be encouraged to discover the relevant concepts.
(iii) Students to be given homework/assignments.
(iv) Discuss and solve the theoretical and practical problems in the class.
(v) Students to be encouraged to apply concepts to real world problems.</td><td rowspan="4">• Presentations and class discussions.
• Assignments and class tests.
• Mid-term examinations.
• Viva-voce examinations.
• End-term examinations.</td></tr>
<tr><td>2.</td><td>Learn about structured data-types in C++ and learn about applications in factorization of an integer and understanding Cartesian geometry and Pythagorean triples.</td></tr>
<tr><td>3.</td><td>Use of containers and templates in various applications in algebra.</td></tr>
<tr><td>4.</td><td>Use mathematical libraries for computational objectives.
Represent the outputs of programs visually in terms of well formatted text and plots.</td></tr>
</table>

Keywords: Array, Class, Command-line Argument, Constructor, Containers, Data-type, Debugging, Destructor, Multiset, Map, Object, Polymorphism, Queue, Vector.

Discipline Specific Elective (DSE) Course - 2

Any *one* of the following (at least *two* shall be offered by the college):

DSE-2 (i): Probability Theory and Statistics
DSE-2 (ii): Discrete Mathematics
DSE-2 (iii): Cryptography and Network Security

DSE-2 (i): Probability Theory and Statistics

Total Marks: 100 (Theory: 75 + Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: To make the students familiar with the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness. The course intends to render the students to several examples and exercises that blend their everyday experiences with their scientific interests.

Course Learning Outcomes: This course will enable the students to:

i) Learn about probability density and moment generating functions.
ii) Know about various univariate distributions such as Bernoulli, Binomial, Poisson, gamma and exponential distributions.
iii) Learn about distributions to study the joint behavior of two random variables.
iv) Measure the scale of association between two variables, and to establish a formulation helping to predict one variable in terms of the other, i.e., correlation and linear regression.
v) Understand central limit theorem, which helps to understand the remarkable fact that**:** the empirical frequencies of so many natural populations, exhibit a bell-shaped curve, i.e., a normal distribution.

Unit 1: Probability Functions and Moment Generating Function
Sample space, Probability set function, Real random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions, Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.

Unit 2: Univariate Discrete and Continuous Distributions
Discrete distributions**:** Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions**:** Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.

Unit 3: Bivariate Distribution
Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.

Unit 4: Correlation, Regression and Central Limit Theorem
The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, Method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.

References:
1. Hogg, Robert V., McKean, Joseph W., & Craig, Allen T. (2013). *Introduction to Mathematical Statistics* (7th ed.). Pearson Education, Inc.
2. Miller, Irwin & Miller, Marylees. (2014). John E. Freund's *Mathematical Statistics with*
   Applications (8th ed.). Pearson. Dorling Kindersley (India).
3. Ross, Sheldon M. (2014). *Introduction to Probability Models* (11th ed.). Elsevier Inc.

Additional Reading:
i. Mood, A. M., Graybill, F. A. & Boes, D. C. (1974). *Introduction to the Theory of Statistics* (3rd ed.). McGraw-Hill Education Pvt. Ltd. Indian Edition (2017).

Teaching Plan (DSE-2 (i): Probability Theory and Statistics):
Weeks 1 and 2: Sample space, Probability set function and examples, Random variable, Probability mass/density function, Cumulative distribution function and its properties.
[1] Chapter 1 (Sections 1.1, 1.3 and 1.5).
Week 3 and 4: Discrete and continuous random variables, and Transformations. Expectation of random variables, and some special expectations**:** Mean, Variance, Standard deviation, Moments and moment generating function, Characteristic function.
[1] Chapter 1 (Sections 1.6 to 1.9).
Week 5: The discrete distributions - Uniform, Bernoulli and binomial.
[2] Chapter 5 (Sections 5.2 to 5.4).
Week 6: The discrete distributions - negative Binomial, Geometric and Poisson.
[2] Chapter 5 (Sections 5.5 and 5.7).
Week 7: The continuous distributions - Uniform, Gamma, Exponential, Chi-square and Beta.
[2] Chapter 6 (Sections 6.2 to 6.4).
Week 8: Normal distribution, and normal approximation to the binomial distribution.
[2] Chapter 6 (Sections 6.5 and 6.6).
Weeks 9 and 10: Random vector**:** Discrete and continuous, Joint cumulative distribution function and its properties, Joint probability mass/density function, Marginal probability mass function, and expectation of two random variables, Joint moment generating function, Conditional distributions and expectations.
[1] Chapter 2 (Sections 2.1 and 2.3).
Week 11: Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables.
[1] Chapter 2 (Sections 2.4 and 2.5).
Week 12: Linear regression for two variables, and the method of least squares.
[2] Chapter 14 (Sections 14.1 to 14.3).
Week 13: Bivariate normal distribution; Chebyshev's theorem.
[2] Chapter 6 (Section 6.7), and Chapter 4 (Section 4.4).
Week 14: Statement and interpretation of the strong law of large numbers, Central limit theorem and the weak law of large numbers.
[3] Chapter 2 (Section 2.8, and Exercise 76, Page 89).

Facilitating the Achievement of Course Learning Outcomes

<table>
<tr><th>Unit No.</th><th>Course Learning Outcomes</th><th>Teaching and Learning Activity</th><th>Assessment Tasks</th></tr>
<tr><td>1.</td><td>Learn about probability density and moment generating functions.</td><td rowspan="4">(i) Each topic to be explained with examples.
(ii) Students to be involved in discussions and encouraged to ask questions.
(iii) Students to be given homework/ assignments.
(iv) Students to be encouraged to give short presentations.</td><td rowspan="4">• Presentations and participation in discussions.
• Assignments and class tests.
• Mid-term examinations.
• End-term examinations.</td></tr>
<tr><td>2.</td><td>Know about various univariate distributions such as Bernoulli, Binomial, Poisson, gamma and exponential distributions.</td></tr>
<tr><td>3.</td><td>Learn about distributions to study the joint behavior of two random variables.</td></tr>
<tr><td>4.</td><td>Measure the scale of association between two variables, and to establish a formulation helping to predict one variable in terms of the other, i.e., correlation and linear regression.
Understand central limit theorem, which helps to understand the remarkable fact that: the empirical frequencies of so many natural populations, exhibit a bell-shaped curve, i.e., a normal distribution.</td></tr>
</table>

Keywords: Chebyshev's theorem, Correlation, Distributions, Distribution functions, Expectation, moments, Random variable, Regression.

DSE-2 (ii): Discrete Mathematics

Total Marks: 100 (Theory: 75 + Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: The course aims at introducing the concepts of ordered sets, lattices, sublattices and homomorphisms between lattices. It also includes introduction to modular and distributive lattices along with complemented lattices and Boolean algebra. Then some important applications of Boolean algebra are discussed in switching circuits. The second part of this course deals with introduction to graph theory, paths and circuits, Eulerian circuits, Hamiltonian graphs and finally some applications of graphs to shortest path algorithms.

Course Learning outcomes: After the course, the student will be able to:

i) Understand the notion of ordered sets and maps between ordered sets.
ii) Learn about lattices, modular and distributive lattices, sublattices and homomorphisms between lattices.
iii) Become familiar with Boolean algebra, Boolean homomorphism, Karnaugh diagrams, switching circuits and their applications.
iv) Learn about basics of graph theory, including Eulerian graphs, Hamiltonian graphs.
v) Learn about the applications of graph theory in the study of shortest path algorithms.

Unit 1: Ordered Sets
Definitions, Examples and basic properties of ordered sets, Order isomorphism, Hasse diagrams, Dual of an ordered set, Duality principle, Maximal and minimal elements, Building new ordered sets, Maps between ordered sets.

Unit 2: Lattices
Lattices as ordered sets, Lattices as algebraic structures, Sublattices, Products and homomorphisms; Definitions, Examples and properties of modular and distributive lattices, The $M_3 - N_5$ theorem with applications, Complemented lattice, Relatively complemented lattice, Sectionally complemented lattice.

Unit 3: Boolean Algebras and Switching Circuits
Boolean algebras, De Morgan's laws, Boolean homomorphism, Representation theorem; Boolean polynomials, Boolean polynomial functions, Disjunctive normal form and conjunctive normal form, Minimal forms of Boolean polynomial, Quine–McCluskey method, Karnaugh diagrams, Switching circuits and applications of switching circuits.

Unit 4: Graph Theory
Introduction to graphs, Königsberg bridge problem, Instant insanity game; Definition, examples and basic properties of graphs, Subgraphs, Pseudographs, Complete graphs, Bipartite graphs, Isomorphism of graphs, Paths and circuits, Eulerian circuits, Hamiltonian cycles, Adjacency matrix, Weighted graph, Travelling salesman problem, Shortest path, Dijkstra's algorithm.

References:

1. Davey, B. A., & Priestley, H. A. (2002). *Introduction to Lattices and Order* (2nd ed.). Cambridge University press, Cambridge.
2. Goodaire, Edgar G., & Parmenter, Michael M. (2011). *Discrete Mathematics with Graph Theory* (3rd ed.). Pearson Education (Singapore) Pvt. Ltd. Indian Reprint.
3. Lidl, Rudolf & Pilz, Gunter. (2004). *Applied Abstract Algebra* (2nd ed.), Undergraduate Texts in Mathematics. Springer (SIE). Indian Reprint.

Additional Reading:

i. Rosen, Kenneth H. (2012). *Discrete Mathematics and its Applications, with Combinatorics and Graph Theor*y. (7th ed.). McGraw-Hill Education. Indian Reprint.

Teaching Plan (DSE-2 (ii): Discrete Mathematics):

Weeks 1 and 2: Definitions, Examples and basic properties of ordered sets, Order isomorphism, Hasse diagrams, dual of an ordered set, Duality principle, Maximal and minimal elements, Building new ordered sets, Maps between ordered sets.

[1] Chapter 1 (Sections 1.1 to 1.5, Sections 1.14 to 1.26, and Sections 1.34 to 1.36).

[3] Chapter 1 [Section 1 (1.1 to 1.3)].

Weeks 3 and 4: Lattices as ordered sets, Lattices as algebraic structures, Sublattices, Products and homomorphisms.

[1] Chapter 2 (Sections 2.1 to 2.19).

[3] Chapter 1 [Section 1 (1.5 to 1.20)].

Week 5: Definitions, Examples and properties of Modular and distributive lattices.

[1] Chapter 4 (Sections 4.1 to 4.9).

[3] Chapter 1 [Section 2 (2.1 to 2.6).

Week 6: $M_3 - N_5$ theorem with applications, Complemented lattice, Relatively complemented lattice, Sectionally complemented lattice.

[1] Chapter 4 (Sections 4.10 and 4.11).

[3] Chapter 1 [Section 2 (2.7 to 2.14)].

Weeks 7 and 8: Boolean algebras, De Morgan’s laws, Boolean homomorphism, representation theorem, Boolean polynomials, Boolean polynomial functions, Disjunctive normal form and conjunctive normal form.

[3] Chapter 1 (Sections 3 and 4).

Week 9: Minimal forms of Boolean polynomial, Quine−McCluskey method, Karnaugh diagrams.

[3] Chapter 1 (Section 6).

Week 10: Switching circuits and applications of switching circuits.

[3] Chapter 2 (Sections 7 and 8).

Weeks 11 and 12: Introduction to graphs, Königsberg bridge problem, Instant insanity game. Definition, Examples and basic properties of graphs, Subgraphs, Pseudographs, Complete graphs, Bipartite graphs, Isomorphism of graphs.

[2] Chapter 9 [Sections 9.1, 9.2 (9.2.1, 9.2.7) and 9.3].

Weeks 13 and 14: Paths and circuits, Eulerian circuits, Hamiltonian cycles, Adjacency matrix, Weighted graph, Travelling salesman problem, shortest path, Dijkstra’s algorithm.

[2] Chapter 10 [Sections 10.1 to 10.4 (10.4.1 to 10.4.3)].

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understand the notion of ordered sets and maps between ordered sets.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be encouraged to give short presentations.	• Presentations and participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Learn about lattices, modular and distributive lattices, sublattices and homomorphisms between lattices.		
3.	Become familiar with Boolean algebra, Boolean homomorphism, Karnaugh diagrams, switching circuits and their applications.		
4.	Learn about basics of graph theory, including Eulerian graphs, Hamiltonian graphs. Learn about the applications of graph theory in the study of shortest path algorithms.		

Keywords: Boolean algebra, Lattices, Graphs, Modularity, Ordered sets, Paths and circuits, Shortest path algorithms, Switching circuits.

DSE-2 (iii): Cryptography and Network Security

Total Marks: 100 (Theory: 75 + Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: This course helps the students to develop skills and knowledge of standard concepts in cryptography and demonstrates how cryptography plays an important role in the present digital world by knowing encryption and decryption techniques and secure data in transit across data networks.

Course Learning Outcomes: After the course, the student will be able to:

i) Understand the fundamentals of cryptography and computer security attacks.
ii) Learn about various ciphers and data encryption standard.
iii) Review basic concepts of number theory and finite fields.
iv) Learn about advanced encryption standard.
v) Understand the fundamentals of RSA and elliptic curve cryptography.
vi) Encrypt and decrypt messages using block ciphers, sign and verify messages using well known signature generation and verification algorithms.

Unit 1: Cryptography and Data Encryption Standard (DES)
Overview of Cryptography, Computer security concepts, Security attacks, Symmetric cipher model, Cryptanalysis and brute-force attack, Substitution techniques, Caesar cipher, Monoalphabetic ciphers, Playfair cipher, Hill cipher, Polyalphabetic ciphers, One-time pad, Transposition techniques, Binary and ASCII, Pseudo-random bit generation, Stream ciphers and Block ciphers, Feistal cipher, Data encryption standard (DES), DES example.

Unit 2: Algorithms and Advanced Encryption Standard (AES)
Review of basic concepts in Number theory and Finite Fields**:** divisibility, polynomial and modular arithmetic, Fermat's and Euler's theorems, Chinese remainder theorem, Discrete logarithm, Finite fields of the form GF(p) and GF(2^n); Advanced encryption standard (AES), AES transformation functions, AES key expansion, AES example.

Unit 3: Public-key Cryptography
Principles of public-key cryptosystems, RSA algorithm and security of RSA, Elliptic curve arithmetic, Elliptic curve cryptography, Cryptographic Hash functions, Secure Hash algorithm.

Unit 4: Digital Signatures and Network Security
Digital signatures, Elgamal and Schnorr digital signature schemes, Digital signature algorithm. Wireless network and mobile device security, Email architecture, formats, threats and security, Secure/Multipurpose Internet Mail Extension, Pretty Good Privacy.

References:

1. Stallings, William (2017). *Cryptography and Network Security*, *Principles and Practice* (7th ed.). Pearson Education Limited. England.
2. Trappe, Wade & Washington, Lawrence C. (2006). *Introduction to Cryptography with Coding Theory* (2nd ed.). Pearson Education International.

Additional Reading:

i. Stinson, Douglas R. (2005). *Cryptography Theory and Practice* (3rd ed.). CRC Press.

Teaching Plan (DSE-2 (iii): Cryptography and Network Security):

Weeks 1 and 2: Overview of Cryptography, Computer security concepts, Security attacks, Symmetric cipher model, Cryptanalysis and brute-force attack, Substitution techniques, Caesar cipher, Monoalphabetic ciphers, Playfair cipher, Hill cipher, Polyalphabetic ciphers, One-time pad.

[2] Chapter 1.

[1] Chapter 1 (Sections 1.1 and 1.3) and Chapter 3 (Sections 3.1 and 3.2).

Weeks 3 and 4: Transposition techniques, Binary and ASCII, Pseudo-random bit generation, Stream ciphers and Block ciphers, Feistal cipher, Data Encryption Standard (DES), DES example.

[1] Chapter 3 (Section 3.3) and Chapter 4 (Sections 4.1 to 4.3).

[2] Chapter 2 (Sections 2.8 and 2.10).

Weeks 5 and 6: Review of basic concepts in Number theory and Finite Fields: divisibility, polynomial and modular arithmetic, Statements of Fermat's and Euler's theorems, Chinese remainder theorem, Discrete logarithm, Finite fields of the form GF(p) and GF(2^n).

[1] Chapter 1 (Sections 2.1 to 2.3, 2.5, 2.7, and 2.8) and Chapter 5 (Sections 5.4 to 5.6).

Weeks 7 and 8: Advanced encryption standard (AES), AES transformation functions, AES key expansion, AES example.

[1] Chapter 6 [Sections 6.1 to 6.5 (up to Page 195)].

Weeks 9 and 10: Principles of public-key cryptosystems, RSA algorithm and security of RSA, Elliptic curve arithmetic, Elliptic curve cryptography.

[1] Chapter 9 (Sections 9.1 and 9.2), and Chapter 10 (Sections 10.3 and 10.4).

Week 11: Cryptographic Hash functions, Secure Hash algorithm.

[1] Sections 11.1 and 11.5.

Weeks 12 and 13: Digital signatures, Elgamal and Schnorr digital signature schemes, Digital signature algorithm, Wireless network and mobile device security.

[1] Chapter 13 (Sections 13.1 to 13.4) and Chapter 18 (Sections 18.1 and 18.2).

Week 14: Email architecture, threats and security, Secure/Multipurpose Internet Mail Extension (S/MIME) and Pretty Good Privacy (PGP).

[1] Chapter 19 [Sections 19.1 to 19.5 (Confidentiality excluded)].

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understand the fundamentals of cryptography and computer security attacks. Learn about various ciphers and data encryption standard.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/ assignments. (iv) Students to be encouraged to give short presentations.	• Student presentations. • Participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Review basic concepts of number theory and finite fields. Learn about advanced encryption standard.		
3.	Understand the fundamentals of RSA and elliptic curve cryptography.		
4.	Encrypt and decrypt messages using block ciphers, sign and verify messages using well known signature generation and verification algorithms.		

Keywords: Cipher, Encryption, Hash function. Privacy, Public-key, Security.

Semester-VI

BMATH613: Complex Analysis

Total Marks: 150 (Theory: 75, Internal Assessment: 25 and Practical: 50)
Workload: 4 Lectures, 4 Practicals (per week), **Credits:** 6 (4+2)
Duration: 14 Weeks (56 Hrs. Theory + 56 Hrs. Practical) **Examination:** 3 Hrs.

Course Objectives: This course aims to introduce the basic ideas of analysis for complex functions in complex variables with visualization through relevant practicals. Emphasis has been laid on Cauchy's theorems, series expansions and calculation of residues.

Course Learning Outcomes: The completion of the course will enable the students to:

i) Learn the significance of differentiability of complex functions leading to the understanding of Cauchy–Riemann equations.
ii) Learn some elementary functions and valuate the contour integrals.
iii) Understand the role of Cauchy–Goursat theorem and the Cauchy integral formula.
iv) Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities, find residues and apply Cauchy Residue theorem to evaluate integrals.

Unit 1: Analytic Functions and Cauchy–Riemann Equations
Functions of complex variable, Mappings; Mappings by the exponential function, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulae, Cauchy–Riemann equations, Sufficient conditions for differentiability; Analytic functions and their examples.

Unit 2: Elementary Functions and Integrals
Exponential function, Logarithmic function, Branches and derivatives of logarithms, Trigonometric function, Derivatives of functions, Definite integrals of functions, Contours, Contour integrals and its examples, Upper bounds for moduli of contour integrals,

Unit 3: Cauchy's Theorems and Fundamental Theorem of Algebra
Antiderivatives, Proof of antiderivative theorem, Cauchy–Goursat theorem, Cauchy integral formula; An extension of Cauchy integral formula, Consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra.

Unit 4: Series and Residues
Convergence of sequences and series, Taylor series and its examples; Laurent series and its examples, Absolute and uniform convergence of power series, Uniqueness of series representations of power series, Isolated singular points, Residues, Cauchy's residue theorem, residue at infinity; Types of isolated singular points, Residues at poles and its examples.

Reference:

1. Brown, James Ward, & Churchill, Ruel V. (2014). *Complex Variables and Applications* (9th ed.). McGraw-Hill Education. New York.

Additional Readings:

i. Bak, Joseph & Newman, Donald J. (2010). *Complex Analysis* (3rd ed.). Undergraduate Texts in Mathematics, Springer. New York.
ii. Zills, Dennis G., & Shanahan, Patrick D. (2003). *A First Course in Complex Analysis with Applications*. Jones & Bartlett Publishers, Inc.
iii. Mathews, John H., & Howell, Rusell W. (2012). *Complex Analysis for Mathematics and Engineering* (6th ed.). Jones & Bartlett Learning. Narosa, Delhi. Indian Edition.

Practical / Lab work to be performed in Computer Lab:

Modeling of the following similar problems using Mathematica/Maple/MATLAB/Maxima/ Scilab etc.

1. Make a geometric plot to show that the n^{th} roots of unity are equally spaced points that lie on the unit circle $C_1(0) = \{z : |z| = 1\}$ and form the vertices of a regular polygon with n sides, for $n = 4, 5, 6, 7, 8$.
2. Find all the solutions of the equation $z^3 = 8i$ and represent these geometrically.
3. Write parametric equations and make a parametric plot for an ellipse centered at the origin with horizontal major axis of 4 units and vertical minor axis of 2 units. Show the effect of rotation of this ellipse by an angle of $\frac{\pi}{6}$ radians and shifting of the centre from (0,0) to (2,1), by making a parametric plot.
4. Show that the image of the open disk $D_1(-1-i) = \{z : |z+1+i| < 1\}$ under the linear transformation $w = f(z) = (3-4i)z + 6 + 2i$ is the open disk:
$$D_5(-1+3i) = \{w: |w+1-3i| < 5\}.$$
5. Show that the image of the right half plane $\operatorname{Re} z = x > 1$ under the linear transformation $w = (-1+i)z - 2 + 3i$ is the half plane $v > u + 7$, where $u = \operatorname{Re}(w)$, etc. Plot the map.
6. Show that the image of the right half plane $A = \{z : \operatorname{Re} z \geq \frac{1}{2}\}$ under the mapping $w = f(z) = \frac{1}{z}$ is the closed disk $\overline{D_1(1)} = \{w : |w-1| \leq 1\}$ in the w- plane.
7. Make a plot of the vertical lines $x = a$, for $a = -1, -\frac{1}{2}, \frac{1}{2}, 1$ and the horizontal lines $y = b$, for $b = -1, -\frac{1}{2}, \frac{1}{2}, 1$. Find the plot of this grid under the mapping $w = f(z) = \frac{1}{z}$.
8. Find a parametrization of the polygonal path $C = C_1 + C_2 + C_3$ from $-1+i$ to $3-i$, where C_1 is the line from: $-1+i$ to -1, C_2 is the line from: -1 to $1+i$ and C_3 is the line from $1+i$ to $3-i$. Make a plot of this path.
9. Plot the line segment 'L' joining the point $A = 0$ to $B = 2 + \frac{\pi}{4}i$ and give an exact calculation of $\int_L e^z dz$.
10. Plot the semicircle 'C' with radius 1 centered at $z = 2$ and evaluate the contour integral $\int_C \frac{1}{z-2} dz$.
11. Show that $\int_{C_1} z dz = \int_{C_2} z dz = 4 + 2i$ where C_1 is the line segment from $-1-i$ to $3+i$ and C_2 is the portion of the parabola $x = y^2 + 2y$ joining $-1-i$ to $3+i$. Make plots of two contours C_1 and C_2 joining $-1-i$ to $3+i$.

12. Use ML inequality to show that $\left|\int_C \frac{1}{z^2+1}dz\right| \leq \frac{1}{2\sqrt{5}}$, where C is the straight line segment from 2 to $2 + i$. While solving, represent the distance from the point z to the points i and $-i$, respectively, i.e. $|z-i|$ and $|z+i|$ on the complex plane $\mathbb{C}$.
13. Show that $\int_C \frac{dz}{2z^{1/2}}$, where $z^{1/2}$ is the principal branch of the square root function and C is the line segment joining 4 to $8 + 6i$. Also plot the path of integration.
14. Find and plot three different Laurent series representations for the function $f(z) = \frac{3}{2+z-z^2}$, involving powers of z.
15. Locate the poles of $f(z) = \frac{1}{5z^4+26z^2+5}$ and specify their order.
16. Locate the zeros and poles of $g(z) = \frac{\pi\cot(\pi z)}{z^2}$ and determine their order. Also justify that Res$(g, 0) = -\pi^2/3$.
17. Evaluate $\int_{C_1^+(0)} \exp\left(\frac{2}{z}\right) dz$, where $C_1^+(0)$ denotes the circle $\{z : |z| = 1\}$ with positive orientation. Similarly evaluate $\int_{C_1^+(0)} \frac{1}{z^4+z^3-2z^2} dz$.

Note: For practicals: Sample materials of files in the form Mathematica/Maple 2011.zip, www.jblearning.com/catalog/9781449604455/.

Teaching Plan (Theory of BMATH613: Complex Analysis):

Week 1: Functions of complex variable, Mappings, Mappings by the exponential function.
[1] Chapter 2 (Sections 12 to 14).

Week 2: Limits, Theorems on limits, Limits involving the point at infinity, Continuity.
[1] Chapter 2 (Sections 15 to 18).

Week 3: Derivatives, Differentiation formulae, Cauchy-Riemann equations, Sufficient conditions for differentiability.
[1] Chapter 2 (Sections 19 to 22).

Week 4: Analytic functions, Examples of analytic functions, Exponential function.
[1] Chapter 2 (Sections 24 and 25) and Chapter 3 (Section 29).

Week 5: Logarithmic function, Branches and Derivatives of Logarithms, Trigonometric functions.
[1] Chapter 3 (Sections 30, 31 and 34).

Week 6: Derivatives of functions, Definite integrals of functions, Contours.
[1] Chapter 4 (Sections 37 to 39).

Week 7: Contour integrals and its examples, upper bounds for moduli of contour integrals.
[1] Chapter 4 (Sections 40, 41 and 43).

Week 8: Antiderivatives, proof of antiderivative theorem.
[1] Chapter 4 (Sections 44 and 45).

Week 9: State Cauchy–Goursat theorem, Cauchy integral formula.
[1] Chapter 4 (Sections 46 and 50).

Week 10: An extension of Cauchy integral formula, Consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra.
[1] Chapter 4 (Sections 51 to 53).

Week 11: Convergence of sequences, Convergence of series, Taylor series, proof of Taylor's theorem, Examples.
[1] Chapter 5 (Sections 55 to 59).

Week 12: Laurent series and its examples, Absolute and uniform convergence of power series, uniqueness of series representations of power series.
[1] Chapter 5 (Sections 60, 62, 63 and 66).

Week 13: Isolated singular points, Residues, Cauchy's residue theorem, Residue at infinity.

[1]: Chapter 6 (Sections 68 to 71).
Week 14: Types of isolated singular points, Residues at poles and its examples.
[1] Chapter 6 (Sections 72 to 74).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Learn the significance of differentiability of complex functions leading to the understanding of Cauchy–Riemann equations.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2.	Learn some elementary functions and valuate the contour integrals.		
3.	Understand the role of Cauchy–Goursat theorem and the Cauchy integral formula.		
4.	Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities, find residues and apply Cauchy Residue theorem to evaluate integrals.		

Keywords: Analytic functions, Antiderivatives, Cauchy–Riemann equations, Cauchy–Goursat theorem, Cauchy integral formula, Cauchy's inequality, Cauchy's residue theorem, Closed contour, Contour integrals, Fundamental theorem of algebra, Liouville's theorem, Morera's theorem, Poles, Regions in complex plane, Residue, Singular points, Taylor's and Laurent's series.

BMATH614: Ring Theory and Linear Algebra-II

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: This course introduces the basic concepts of ring of polynomials and irreducibility tests for polynomials over ring of integers, used in finite fields with applications in cryptography. This course emphasizes the application of techniques using the adjoint of a linear operator and their properties to least squares approximation and minimal solutions to systems of linear equations.

Courses Learning Outcomes: On completion of this course, the student will be able to:

i) Appreciate the significance of unique factorization in rings and integral domains.
ii) Compute the characteristic polynomial, eigenvalues, eigenvectors, and eigenspaces, as well as the geometric and the algebraic multiplicities of an eigenvalue and apply the basic diagonalization result.
iii) Compute inner products and determine orthogonality on vector spaces, including Gram−Schmidt orthogonalization to obtain orthonormal basis.
iv) Find the adjoint, normal, unitary and orthogonal operators.

Unit 1: Polynomial Rings and Unique Factorization Domain (UFD)
Polynomial rings over commutative rings, Division algorithm and consequences, Principal ideal domains, Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein's criterion, Unique factorization in $\mathbb{Z}[x]$; Divisibility in integral domains, Irreducibles, Primes, Unique factorization domains, Euclidean domains.

Unit 2: Dual Spaces and Diagonalizable Operators
Dual spaces, Double dual, Dual basis, Transpose of a linear transformation and its matrix in the dual basis, Annihilators; Eigenvalues, Eigenvectors, Eigenspaces and characteristic polynomial of a linear operator; Diagonalizability, Invariant subspaces and Cayley−Hamilton theorem; Minimal polynomial for a linear operator.

Unit 3: Inner Product Spaces
Inner product spaces and norms, Orthonormal basis, Gram−Schmidt orthogonalization process, Orthogonal complements, Bessel's inequality.

Unit 4: Adjoint Operators and Their Properties
Adjoint of a linear operator, Least squares approximation, Minimal solutions to systems of linear equations, Normal, self-adjoint, unitary and orthogonal operators and their properties.

References:

1. Friedberg, Stephen H., Insel, Arnold J., & Spence, Lawrence E. (2003). *Linear Algebra* (4th ed.). Prentice-Hall of India Pvt. Ltd. New Delhi.
2. Gallian, Joseph. A. (2013). *Contemporary Abstract Algebra* (8th ed.). Cengage Learning India Private Limited. Delhi. Fourth impression, 2015.

Additional Readings:

i. Herstein, I. N. (2006). *Topics in Algebra* (2nd ed.). Wiley Student Edition. India.
ii. Hoffman, Kenneth, & Kunze, Ray Alden (1978). *Linear Algebra* (2nd ed.). Prentice-Hall of India Pvt. Limited. Delhi. Pearson Education India Reprint, 2015.

iii. Lang, Serge (1987). *Linear Algebra* (3rd ed.). Springer.

Teaching Plan (BMATH614: Ring Theory and Linear Algebra-II):

Week 1: Polynomial rings over commutative rings, Division algorithm and consequences, Principal ideal domains.
[2] Chapter 16.

Weeks 2 and 3: Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein's criterion, Unique factorization in $\mathbb{Z}[x]$.
[2] Chapter 17.

Weeks 4 and 5: Divisibility in integral domains, Irreducibles, Primes, Unique factorization domains, Euclidean domains.
[2] Chapter 18.

Week 6: Dual spaces, Double dual, Dual basis, Transpose of a linear transformation and its matrix in dual basis**,** Annihilators.
[1] Chapter 2 (Section 2.6).

Weeks 7 and 8: Eigenvalues, Eigenvectors, Eigenspaces and characteristic polynomial of a linear operator; Diagonalizability, Invariant subspaces and Cayley–Hamilton theorem; Minimal polynomial for a linear operator.
[1] Chapter 5 (Sections 5.1, 5.2 and 5.4), Chapter 7 (Section 7.3, Statement of Theorem 7.16)

Week 9: Inner product spaces and norms.
[1] Chapter 6 (Section 6.1).

Weeks 10 and 11: Orthonormal basis, Gram–Schmidt orthogonalization process, Orthogonal complements, Bessel's inequality.
[1] Chapter 6 (Section 6.2).

Week 12: Adjoint of a linear operator and its properties, Least squares approximation, Minimal solutions to systems of linear equations.
[1] Chapter 6 (Section 6.3, Statement of Theorem 6.13 with applications).

Weeks 13 and 14: Normal, self-adjoint, unitary and orthogonal operators and their properties.
[1] Chapter 6 (Sections 6.4, and 6.5, up to Theorem 6.21, Page 385).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Appreciate the significance of unique factorization in rings and integral domains.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignment. (iv) Students to be encouraged to give short presentations.	• Student presentations. • Participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Compute the characteristic polynomial, eigenvalues, eigenvectors, eigenspaces, as well as the geometric and the algebraic multiplicities of an eigenvalue and apply the basic diagonalization result.		
3.	Compute inner products and determine orthogonality on vector spaces, including Gram–Schmidt orthogonalization to obtain orthonormal basis.		
4.	Find the adjoint, normal, unitary and orthogonal operators.		

Keywords: Bessel's inequality, Cayley–Hamilton theorem, Eigenvalues and eigenvectors, Eisenstein's criterion, Euclidean domains, Inner product spaces, Orthonormal basis, Principal ideal domains, Unique factorization domains, Normal, self-adjoint and unitary operators.

Discipline Specific Elective (DSE) Course - 3

Any *one* of the following (at least *two* shall be offered by the college):

DSE-3 (i): Mathematical Finance
DSE-3 (ii): Introduction to Information Theory and Coding
DSE-3 (iii): Biomathematics

DSE-3 (i): Mathematical Finance

Total Marks: 100 (Theory: 75 + Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: This course is an introduction to the application of mathematics in financial world, that enables the student to understand some computational and quantitative techniques required for working in the financial markets and actuarial mathematics.

Course Learning outcomes: On completion of this course, the student will be able to:
- i) Know the basics of financial markets and derivatives including options and futures.
- ii) Learn about pricing and hedging of options, as well as interest rate swaps.
- iii) Learn about no-arbitrage pricing concept and types of options.
- iv) Learn stochastic analysis (Ito formula, Ito integration) and the Black–Scholes model.
- v) Understand the concepts of trading strategies and valuation of currency swaps.

Unit 1: Interest Rates
Interest rates, Types of rates, Measuring interest rates, Zero rates, Bond pricing, Forward rate, Duration, Convexity, Exchange traded markets and OTC markets, Derivatives--forward contracts, Futures contract, Options, Types of traders, Hedging, Speculation, Arbitrage.

Unit 2: Mechanics and Properties of Options

No Arbitrage principle, Short selling, Forward price for an investment asset, Types of options, Option positions, Underlying assets, Factors affecting option prices, Bounds on option prices, Put-call parity, Early exercise, Effect of dividends.

Unit 3: Stochastic Analysis of Stock Prices and Black-Scholes Model

Binomial option pricing model, Risk neutral valuation (for European and American options on assets following binomial tree model), Lognormal property of stock prices, Distribution of rate of return, expected return, Volatility, estimating volatility from historical data, Extension of risk neutral valuation to assets following GBM, Black–Scholes formula for European options.

Unit 4: Hedging Parameters, Trading Strategies and Swaps

Hedging parameters (the Greeks: Delta, Gamma, Theta, Rho and Vega), Trading strategies involving options, Swaps, Mechanics of interest rate swaps, Comparative advantage argument, Valuation of interest rate swaps, Currency swaps, Valuation of currency swaps.

Reference:
1. Hull, J. C., & Basu, S. (2010). *Options, Futures and Other Derivatives* (7th ed.). Pearson Education. New Delhi.

Additional Readings:

i. Luenberger, David G. (1998). *Investment Science*, Oxford University Press. Delhi.
ii. Ross, Sheldon M. (2011). *An elementary Introduction to Mathematical Finance* (3rd ed.). Cambridge University Press. USA.

Teaching Plan (DSE-3 (i): Mathematical Finance):

Weeks 1 and 2: Interest rates, Types of rates, Measuring interest rates, Zero rates, Bond pricing, Forward rate, Duration, Convexity.
[1] Chapter 4 (Section 4.1 to 4.4, 4.6, 4.8 and 4.9).

Weeks 3 and 4: Exchange traded markets and OTC markets, Derivatives- forward contracts, Futures contract, Options, Types of traders, Hedging, Speculation, Arbitrage**.**
[1] Chapter 1 (Sections 1.1 to 1.9).

Week 5: No Arbitrage principle, Short selling, Forward price for an investment asset.
[1] Chapter 5 (Sections 5.2 to 5.4).

Week 6: Types of options, Option positions, Underlying assets, Factors affecting option prices.
[1] Chapter 8 (Sections 8.1 to 8.3), and Chapter 9 (Section 9.1).

Week 7: Bounds on option prices, Put-call parity, Early exercise, Effect of dividends.
[1] Chapter 9 (Sections 9.2 to 9.7).

Week 8: Binomial option pricing model, Risk neutral valuation (for European and American options on assets following binomial tree model).
[1] Chapter 11 (Sections 11.1 to 11.5).

Weeks 9 to 11: Lognormal property of stock prices, Distribution of rate of return, expected return, Volatility, estimating volatility from historical data. Extension of risk neutral valuation to assets following GBM (without proof), Black−Scholes formula for European options.
[1] Chapter 13 (Sections 13.1 to 13.4, 13.7 and 13.8).

Week 12: Hedging parameters (the Greeks: Delta, Gamma, Theta, Rho and Vega).
[1] Chapter 17 (Sections 17.1 to 17.9).

Week 13: Trading strategies Involving options.
[1] Chapter 10 (except box spreads, calendar spreads and diagonal spreads).

Week 14: Swaps, Mechanics of interest rate swaps, Comparative advantage argument, Valuation of interest rate swaps, Currency swaps, Valuation of currency swaps
[1] Chapter 7 (Sections 7.1 to 7.4 and 7.7 to 7.9).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Know the basics of financial markets and derivatives including options and futures. Learn about pricing and hedging of options, as well as interest rate swaps.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be encouraged to give short presentations.	• Student presentations. • Participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Learn about no-arbitrage pricing concept and types of options.		
3.	Learn stochastic analysis (Ito formula and Ito integration) and the Black−Scholes model.		
4.	Find the adjoint, normal, unitary and orthogonal operators.		

Keywords: Black−Scholes model, Forward contracts, Futures contract, Options, Hedging, Speculation, Arbitrage, Put-call parity, Short sellings, Swaps.

DSE-3 (ii): Introduction to Information Theory and Coding

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination**: 3 Hrs.

Course Objectives: This course aims to introduce the basic aspects of Information Theory and Coding to the students. Shannon's work form the underlying theme for the present course. Construction of finite fields and bounds on the parameters of a linear code discussed.

Course Learning Outcomes: This course will enable the students to:

i) Learn about the basic concepts of information theory.
ii) Know about basic relationship among different entropies and interpretation of Shannon's fundamental inequalities.
iii) Learn about the detection and correction of errors while transmission.
iv) Representation of a linear code by matrices.
v) Learn about encoding and decoding of linear codes.

Unit 1: Concepts of Information Theory
Communication processes, A model of communication system, A quantitative measure of information, Binary unit of information, A measure of uncertainty, H function as a measure of uncertainty, Sources and binary sources, Measure of information for two-dimensional discrete finite probability schemes.

Unit 2: Entropy Function
A sketch of communication network, Entropy, Basic relationship among different entropies, A measure of mutual information, Interpretation of Shannon's fundamental inequalities; Redundancy, Efficiency and channel capacity, Binary symmetric channel, Binary erasure channel, Uniqueness of the entropy function, Joint entropy and conditional entropy, Relative entropy and mutual information, Chain rules for entropy, Conditional relative entropy and conditional mutual information, Jensen's inequality and its characterizations, The log sum inequality and its applications.

Unit 3: Concepts of Coding
Block codes, Hamming distance, Maximum likelihood decoding, Levels of error handling, Error correction, Error detection, Erasure correction, Construction of finite fields, Linear codes, Matrix representation of linear codes.

Unit 4: Bounds of Codes
Orthogonality relation, Encoding of linear codes, Decoding of linear codes, Singleton bound and maximum distance separable codes, Sphere-packing bound and perfect codes, Gilbert–Varshamov bound, MacWilliams' identities.

References:

1. Cover, Thomas M., & Thomas, Joy A. (2006). *Elements of Information Theory* (2nd ed.). Wiley India. Indian Reprint 2014.
2. Gallian, Joseph. A. (2013). *Contemporary Abstract Algebra* (8th ed.). Cengage Learning India Private Limited. Delhi. Fourth impression, 2015.

3. Reza, Fazlollah M. (1961). *An Introduction to Information Theory*. Dover Publications Inc, New York. Reprint 1994.
4. Roth, Ron M. (2007). *Introduction to Coding Theory*. Cambridge University Press.

Additional Readings:

i. Ash, Robert B. (1965). *Information Theory*. Dover Publications, Inc. New York. Reprint in 1990.
ii. Goldman, Stanford (1968). *Information Theory*, Dover Publications, Inc. New York. Reprint in 1990.
iii. Ling, San & Xing, Chaoping (2004). *Coding Theory*: *A First Course*. Cambridge University Press.

Teaching Plan (DSE-3 (ii): Introduction to Information Theory and Coding):

Weeks 1 and 2: Communication processes, A model of communication system, A quantitative measure of information, Binary unit of information.
[3] Chapter 1 (Sections 1.1 to 1.7).

Weeks 3 and 4: A measure of uncertainty, H function as a measure of uncertainty, Sources and binary sources, Measure of information for two-dimensional discrete finite probability schemes.
[3] Chapter 3 (Sections 3.1 to 3.7).

Weeks 5 and 6: A sketch of communication network, Entropy, Basic relationship among different entropies, A measure of mutual information, Interpretation of Shannon's fundamental inequalities; redundancy, efficiency and channel capacity, Binary symmetric channel, Binary erasure channel, Uniqueness of the entropy function.
[3] Chapter 3 (Sections 3.9, 3.11 to 3.16 and 3.19).
[1] Chapter 2 (Section 2.1).

Weeks 7 and 8: Joint entropy and conditional entropy, Relative entropy and mutual information, Chain rules for entropy, Conditional relative entropy and conditional mutual information, Jensen's inequality and its characterizations, The log sum inequality and its applications.
[1] Chapter 2 (Sections 2.2 to 2.7).

Weeks 9 and 10: Block codes, Hamming distance, Maximum likelihood decoding, Levels of error handling, Error correction, Error detection, Erasure correction, Construction of finite fields.
[4] Chapter 1 (Sections 1.2 to 1.5, excluding 1.5.3), and Chapter 3 (Sections 3.1 to 3.4).

Weeks 11 and 12: Linear codes, Matrix representation of linear codes, Orthogonality relation, Encoding of linear codes, Decoding of linear codes.
[4] Chapter 2 (Sections 2.1 to 2.4).
[2] Chapter 31 (Lemma and Theorem 31.3 on Page 538).

Weeks 13 and 14: Singleton bound and maximum distance separable codes, Sphere-packing bound and perfect codes, Gilbert–Varshamov bound, MacWilliams' identities.
[4] Chapter 4 (Sections 4.1 to 4.4) and Chapter 11 (Section 11.1).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
1.	Learn about the basic concepts of information theory.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given	• Student presentations. • Participation in discussions. • Assignments
2.	Know about basic relationship among different entropies and interpretation of Shannon's fundamental inequalities.		

3.	Learn about the detection and correction of errors while transmission.	homework/assignments. (iv) Students to be encouraged to give short presentations.	and class tests. • Mid-term examinations. • End-term examinations.
4.	Representation of a linear code by matrices. Learn about encoding and decoding of linear codes.		

Keywords: Measure of uncertainty, Entropy, Shannon's fundamental inequalities, Channel capacity, Linear codes, Gilbert–Varshamov bound.

DSE-3 (iii): Biomathematics

Total Marks: 100 (Theory: 75 + Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: The focus of the course is on scientific study of normal functions in living systems. The emphasis is on exposure to nonlinear differential equations with examples such as heartbeat, chemical reactions and nerve impulse transmission. The basic concepts of the probability to understand molecular evolution and genetics have also been applied.

Course Learning outcomes: Apropos conclusion of the course will empower the student to:

i) Learn the development, analysis and interpretation of bio mathematical models such as population growth, cell division, and predator-prey models.
ii) Learn about the mathematics behind heartbeat model and nerve impulse transmission model.
iii) Appreciate the theory of bifurcation and chaos.
iv) Learn to apply the basic concepts of probability to molecular evolution and genetics.

Unit 1: Modeling Biological Phenomenon
Population growth, Administration of drugs, Cell division, Systems of linear ordinary differential equations, Heartbeat, Nerve impulse transmission, Chemical reactions, Predator-prey models.

Unit 2: Mathematics of Heart Physiology and Nerve Impulse Transmission
Stability and oscillations**:** Epidemics, Phase plane and Jacobian matrix, Local stability, Stability, Limit cycles, Forced oscillations; Mathematics of heart physiology**:** local model, threshold effect, phase plane analysis and heartbeat model, A model of the cardiac pacemaker; Mathematics of nerve impulse transmission**:** excitability and repetitive firing, travelling waves.

Unit 3: Bifurcation and Chaos
Bifurcation, Bifurcation of a limit cycle, Discrete bifurcation and period-doubling, Chaos, Stability of limit cycles, Poincaré plane.

Unit 4: Modeling Molecular Evolution and Genetics
Modelling Molecular Evolution**:** Matrix models of base substitutions for DNA sequences, Jukes–Cantor model, Kimura models, Phylogenetic distances; Constructing Phylogenetic Trees**:** Phylogenetic trees, Unweighted pair-group method with arithmetic means (UPGMA), Neighbor joining method; Genetics**:** Mendelian genetics, Probability distributions in genetics.

References:

1. Allman, Elizabeth S., & Rhodes, John A. (2004). *Mathematical Models in Biology: An Introduction*. Cambridge University Press.
2. Jones, D. S., Plank, M. J., & Sleeman, B. D. (2009). *Differential Equations and Mathematical Biology* (2nd ed.). CRC Press, Taylor & Francis Group, LLC.

Additional Readings:

i. Murray, J. D. (2002). *An Introduction to Mathematical Biology* (3rd ed.). Springer.
ii. Myint-U, Tyn (1977). *Ordinary Differential Equations*. Elsevier North-Holland, Inc.
iii. Simmons, George F., & Krantz, Steven G. (2015). *Differential Equations*. McGraw-Hill Education. Indian Reprint.
iv. Strogatz, Steven H. (2009). *Nonlinear Dynamics and Chaos* (2nd ed.). Perseus Book Publishing. LLC. Sarat Publication, Kolkata, India.

Teaching Plan (DSE-3 (iii): Biomathematics):

Week 1: Population growth, Administration of drugs, Cell division, Systems of linear ordinary differential equations.
[2] Chapter 1 (Sections 1.1 to 1.3) and Chapter 3 (An overview of the methods in Sections 3.1 to 3.6).

Week 2: Heartbeat, Nerve impulse transmission.
[2] Chapter 4 (Sections 4.2, and 4.3).

Week 3: Chemical reactions, Predator-prey models, Epidemics (mathematical model).
[2] Chapter 4 (Sections 4.4 and 4.5) and Chapter 5 (Section 5.2)

Week 4: The phase plane and Jacobian matrix, Local stability.
[2] Chapter 5 (Sections 5.3 and 5.4).

Week 5: Stability, Limit cycles.
[2] Chapter 5 [Sections 5.5, and 5.6 (up to Page number 137)].

Week 6: Limit cycle criterion and Poincaré–Bendixson Theorem (interpretation only, with Example 5.6.1), Forced oscillations.
[2] Chapter 5 [Section 5.6 (Page number 137 to 138) and Section 5.7).

Week 7: Mathematics of heart physiology: local model, threshold effect, phase plane analysis and heartbeat model.
[2] Chapter 6 (Sections 6.1 to 6.3).

Week 8: A model of the cardiac pacemaker, Excitability and repetitive firing.
[2] Chapter 6 (Section 6.5) and Chapter 7 (Section 7.1).

Week 9: Travelling waves, Bifurcation, Bifurcation of a limit cycle.
[2] Chapter 7 (Section 7.2), and Chapter 13 (Sections 13.1 and 13.2).

Weeks 10 and 11: Discrete bifurcation and period-doubling, Chaos, Stability of limit cycles, Poincaré plane.
[2] Chapter 13 (Sections 13.3 to 13.6).

Week 12: Matrix models of base substitutions for DNA sequences, Jukes–Cantor model, Kimura models, Phylogenetic distances.
[1] Chapter 4 (Sections 4.4 and 4.5).

Week 13: Constructing phylogenetic trees: phylogenetic trees, unweighted pair-group method with arithmetic means (UPGMA), Neighbor joining method.
[1] Chapter 5 (Sections 5.1 to 5.3).

Week 14: Genetics**:** Mendelian genetics, probability distributions in genetics.
[1] Chapter 6 [Sections 6.1 and 6.2 (up to Equation 6.2 only)].

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Learn the development, analysis and interpretation of bio mathematical models such as	(i) Each topic to be explained with examples. (ii) Students to be involved in	• Student presentations.

	population growth, cell division, and predator-prey models.	discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be encouraged to give short presentations.	• Participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Learn about the mathematics behind heartbeat model and nerve impulse transmission model.		
3.	Appreciate the theory of bifurcation and chaos.		
4.	Learn to apply the basic concepts of probability to molecular evolution and genetics.		

Keywords: Bifurcation and chaos, Forced oscillations, Jukes–Cantor model, Kimura model, Limit cycles, Phase plane, Phylogenetic distances, Stability, UPGMA.

Discipline Specific Elective (DSE) Course - 4

Any *one* of the following (at least *two* shall be offered by the college):

DSE-4 (i): Number Theory
DSE-4 (ii): Linear Programming and Applications
DSE-4 (iii): Mechanics

DSE-4 (i): Number Theory

Total Marks: 100 (Theory: 75 and Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: In number theory there are challenging open problems which are comprehensible at undergraduate level, this course is intended to build a micro aptitude of understanding aesthetic aspect of mathematical instructions and gear young minds to ponder upon such problems. Also, another objective is to make the students familiar with simple number theoretic techniques, to be used in data security.

Course Learning Outcomes: This course will enable the students to:

i) Learn about some fascinating discoveries related to the properties of prime numbers, and some of the open problems in number theory, viz., Goldbach conjecture etc.
ii) Know about number theoretic functions and modular arithmetic.
iii) Solve linear, quadratic and system of linear congruence equations.
iv) Learn about public key crypto systems, in particular, RSA.

Unit 1: Distribution of Primes and Theory of Congruencies
Linear Diophantine equation, Prime counting function, Prime number theorem, Goldbach conjecture, Fermat and Mersenne primes, Congruence relation and its properties, Linear congruence and Chinese remainder theorem, Fermat's little theorem, Wilson's theorem.

Unit 2: Number Theoretic Functions
Number theoretic functions for sum and number of divisors, Multiplicative function, Möbius inversion formula, Greatest integer function. Euler’s phi-function and properties, Euler’s theorem.

Unit 3: Primitive Roots
The order of an integer modulo *n*, Primitive roots for primes, Composite numbers having primitive roots; Definition of quadratic residue of an odd prime, and Euler’s criterion.

Unit 4: Quadratic Reciprocity Law and Public Key Encryption
The Legendre symbol and its properties, Quadratic reciprocity, Quadratic congruencies with composite moduli; Public key encryption, RSA encryption and decryption.

References:

1. Burton, David M. (2012). *Elementary Number Theory* (7th ed.). Mc-Graw Hill Education Pvt. Ltd. Indian Reprint.

2. Jones, G. A., & Jones, J. Mary. (2005). *Elementary Number Theo*ry. Undergraduate Mathematics Series (SUMS). First Indian Print.

Additional Reading:

i. Neville Robinns. (2007). *Beginning Number Theory* (2nd ed.). Narosa Publishing House Pvt. Limited, Delhi.

Teaching Plan (DSE-4 (i): Number Theory):

Week 1: Linear Diophantine equation and its solutions, Distribution of primes, Prime counting function, Statement of the prime number theorem, Goldbach conjecture.
[1] Chapter 2 (Section 2.5).
[2] Chapter 2 (Section 2.2).

Week 2: Fermat and Mersenne primes, Congruence relation and its basic properties, Linear congruence equation and its solutions.
[2] Chapter 2 (Section 2.3).
[1] Chapter 4 (Sections 4.2 and 4.4).

Week 3: Chinese remainder theorem, to solve system of linear congruence for two variables, Fermat's little theorem, Wilson's theorem.
[1] Chapter 4 (Section 4.4), Chapter 5 (Section 5.2 up to before pseudo-prime at Page 90, Section 5.3).

Weeks 4 and 5: Number theoretic functions for sum and number of divisors, Multiplicative function, and the Möbius inversion formula. The greatest integer function, Euler's phi-function.
[1] Chapter 6 (Sections 6.1 to 6.2) and Chapter 7 (Section 7.2).

Week 6: Euler's theorem, Properties of Euler’s phi-function.
[1] Chapter 7 (Sections 7.3 and 7.4).

Weeks 7 and 8: The order of an integer modulo n. Primitive roots for primes.
[1] Chapter 8 (Sections 8.1 and 8.2).

Week 9: Composite numbers having primitive roots.
[1] Chapter 8 (Section 8.3).

Week 10: Definition of quadratic residue of an odd prime, and Euler's criterion.
[1] Chapter 9 (Section 9.1).

Weeks 11 and 12: The Legendre symbol and its properties. Quadratic reciprocity law.
[1] Chapter 9 (Section 9.2 up to Page 181 and Section 9.3).

Week 13: Quadratic congruencies with composite moduli.
[1] Chapter 9 (Section 9.4).

Week 14: Public key encryption, RSA encryption and decryption scheme.
[1] Section 10.1.

Facilitating the Achievement of Course Learning Outcomes

<table>
<tr><th>Unit No.</th><th>Course Learning Outcomes</th><th>Teaching and Learning Activity</th><th>Assessment Tasks</th></tr>
<tr><td>1.</td><td>Learn about some fascinating discoveries related to the properties of prime numbers, and some of the open problems in number theory, viz., Goldbach conjecture etc.</td><td rowspan="3">(i) Each topic to be explained with examples.
(ii) Students to be involved in discussions and encouraged to ask questions.
(iii) Students to be given homework/assignments.</td><td rowspan="3">• Student presentations.
• Participation in discussions.
• Assignments and class tests.
• Mid-term examinations.</td></tr>
<tr><td>2.</td><td>Know about number theoretic functions and modular arithmetic.</td></tr>
<tr><td>3.</td><td>Solve linear, quadratic and system of linear congruence equations.</td></tr>
</table>

4.	Learn about public key crypto systems, in particular, RSA.	(iv) Students to be encouraged to give short presentations.	• End-term examinations.

Keywords: Congruence, Decryption & Encryption, Legendre symbol, Multiplicative function, Prime numbers, Primitive roots, Reciprocity, Quadratic residue.

DSE-4 (ii): Linear Programming and Applications

Total Marks: 100 (Theory: 75 and Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: This course develops the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research. The course covers Linear rogramming with applications to transportation, assignment and game problem. Such problems arise in manufacturing resource planning and financial sectors.

Course Learning Outcomes: This course will enable the students to:
- i) Learn about the graphical solution of linear programming problem with two variables.
- ii) Learn about the relation between basic feasible solutions and extreme points.
- iii) Understand the theory of the simplex method used to solve linear programming problems.
- iv) Learn about two-phase and big-M methods to deal with problems involving artificial variables.
- v) Learn about the relationships between the primal and dual problems.
- vi) Solve transportation and assignment problems.
- vii) Apply linear programming method to solve two-person zero-sum game problems.

Unit 1: Introduction to Linear Programming
Linear programming problem**:** Standard, Canonical and matrix forms, Graphical solution; Convex and polyhedral sets, Hyperplanes, Extreme points; Basic solutions, Basic feasible solutions, Reduction of feasible solution to a basic feasible solution, Correspondence between basic feasible solutions and extreme points.

Unit 2: Methods of Solving Linear Programming Problem
Simplex method**:** Optimal solution, Termination criteria for optimal solution of the linear programming problem, Unique and alternate optimal solutions, Unboundedness; Simplex algorithm and its tableau format; Artificial variables, Two-phase method, Big-M method.

Unit 3: Duality Theory of Linear Programming
Motivation and formulation of dual problem; Primal-Dual relationships; Fundamental theorem of duality; Complimentary slackness.

Unit 4: Applications
*Transportation Problem***:** Definition and formulation; Methods of finding initial basic feasible solutions; Northwest-corner rule. Least-cost method; Vogel's approximation method; Algorithm for solving transportation problem.

*Assignment Problem***:** Mathematical formulation and Hungarian method of solving.

*Game Theory***:** Basic concept, Formulation and solution of two-person zero-sum games, Games with mixed strategies, Linear programming method of solving a game.

References:
1. Bazaraa, Mokhtar S., Jarvis, John J., & Sherali, Hanif D. (2010). *Linear Programming and Network Flows* (4th ed.). John Wiley and Sons.

2. Hadley, G. (1997). *Linear Programming*. Narosa Publishing House. New Delhi.
3. Taha, Hamdy A. (2010). *Operations Research*: *An Introduction* (9th ed.). Pearson.

Additional Readings:

i. Hillier, Frederick S. & Lieberman, Gerald J. (2015). *Introduction to Operations Research* (10th ed.). McGraw-Hill Education (India) Pvt. Ltd.
ii. Thie, Paul R., & Keough, G. E. (2014). *An Introduction to Linear Programming and Game Theory*. (3rd ed.). Wiley India Pvt. Ltd.

Teaching Plan (DSE-4 (ii): Linear Programming and Applications):

Week 1: Linear programming problem: Standard, Canonical and matrix forms, Graphical solution.
[1] Chapter 1 (Section 1.1).
[2] Chapter 1 (Sections 1.1 to 1.4 and 1.6).

Weeks 2 and 3: Convex and polyhedral sets, Hyperplanes, Extreme points; Basic solutions, Basic feasible solutions; Reduction of any feasible solution to a basic feasible solution; Correspondence between basic feasible solutions and extreme points.
[2] Chapter 2 (Sections 2.16, 2.19 and 2.20), and Chapter 3 (Sections 3.4 and 3.10).
[1] Chapter 3 (Section 3.2).

Week 4: Simplex Method: Optimal solution, Termination criteria for optimal solution of the linear programming problem, Unique and alternate optimal solutions, Unboundedness.
[1] Chapter 3 (Sections 3.3 and 3.6).

Weeks 5 and 6: Simplex algorithm and its tableau format.
[1] Chapter 3 (Sections 3.7 and 3.8).

Weeks 7 and 8: Artificial variables, Two-phase method, Big-M method.
[1] Chapter 4 (Sections 4.1 to 4.3).

Weeks 9 and 10: Motivation and formulation of dual problem; Primal-dual relationships.
[1] Chapter 6 (Section 6.1 and 6.2, up to Example 6.4).

Week 11: Statements of the fundamental theorem of duality and complimentary slackness theorem with examples.
[1] Chapter 6 (Section 6.2).

Weeks 12 and 13: Transportation problem, Assignment problem.
[3] Chapter 5 (Sections 5.1, 5.3 and 5.4).

Week 14: Game Theory**:** Basic concept, Formulation and solution of two-person zero-sum games, Games with mixed strategies, Linear programming method of solving a game.
[2] Chapter 11 (Sections 11.12 and 11.13).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
1.	Learn about the graphical solution of linear programming problem with two variables. Learn about the relation between basic feasible solutions and extreme points.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be encouraged to give short	• Student presentations. • Participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Understand the theory of the simplex method used to solve linear programming problems. Learn about two-phase and big-M methods to deal with problems involving artificial variables.		

3.	Learn about the relationships between the primal and dual problems.	presentations.	
4.	Solve transportation and assignment problems. Apply linear programming method to solve two-person zero-sum game problems.		

Keywords: Artificial variables, Big-M method, Duality, Extreme points and basic feasible solutions, Simplex method, Two-phase method, Vogel's approximation method.

DSE-4 (iii): Mechanics

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination**: 3 Hrs.

Course Objectives: The course aims at understanding the various concepts of physical quantities and the related effects on different bodies using mathematical techniques. It emphasizes knowledge building for applying mathematics in physical world.

Course Learning Outcomes: The course will enable the students to:

i) Know about the concepts in statics such as moments, couples, equilibrium in both two and three dimensions.
ii) Understand the theory behind friction and center of gravity.
iii) Calculate moments of inertia of areas and rigid bodies.
iv) Know about conservation of mechanical energy and work-energy equations.
v) Learn about translational and rotational motion of rigid bodies.

Unit 1: Forces in Equilibrium
Coplanar force systems; Three-dimensional force systems; Moment of a force about a point and an axis, Principle of moments, Couple and couple moment, Moment of a couple about a line, Resultant of a force system, Distributed force system, Rigid-body equilibrium, Equilibrium of forces in two and three dimensions, Free-body diagrams, General equations of equilibrium, Constraints and statical determinacy.

Unit 2: Friction, Center of Gravity and Moments of Inertia
Equations of equilibrium and friction, Frictional forces on screws and flat belts; Center of gravity, Center of mass and Centroid of a body and composite bodies; Theorems of Pappus and Guldinus; Moments and products of inertia for areas, Composite areas and rigid body, Parallel-axis theorem, Moment of inertia of a rigid body about an arbitrary axis, Principal moments and principal axes of inertia.

Unit 3: Conservation of Energy and Applications
Conservative force fields, Conservation of mechanical energy, Work-energy equations, Kinetic energy and work-kinetic energy expressions based on center of mass, Moment of momentum equation for a single particle and a system of particles.

Unit 4: Rigid Body Motion
Translation and rotation of rigid bodies, Chasles' theorem, General relationship between time derivatives of a vector for different references, Relationship between velocities of a particle for different references, Acceleration of particle for different references.

References:

1. Hibbeler, R. C. (2016). *Engineering Mechanics*: *Statics & Dynamics* (14th ed.). Pearson Prentice Hall (Pearson Education), New Jersey.
2. Shames, Irving H., & Rao, G. Krishna Mohan (2009). *Engineering Mechanics*: *Statics and Dynamics* (4th ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi.

Additional Reading:

i. Nelson, E. W., Best, Charles L. & McLean, W. G. (1998). *Theory and Problems of Engineering Mechanics*: *Statics and Dynamics* (5th ed.). McGraw-Hill, Schaum's Outline Series.

Teaching Plan (DSE-4 (iii): Mechanics):

Weeks 1 and 2: Coplanar force systems; Three-dimensional force systems. Moment of a force about a point and an axis, Principle of moments, Couple and couple moment, Moment of a couple about a line, Resultant of a force system, Distributed force system.
[1] Chapters 3 and 4.

Weeks 3 and 4: Rigid-body equilibrium, Equilibrium of forces in two and three dimensions, Free-body diagrams, General equations of equilibrium, Constraints and statical determinacy.
[1] Chapter 5.

Weeks 5 and 6: Equations of equilibrium and friction, Frictional forces on screws and flat belts; Center of gravity, Center of mass and Centroid of a body and composite bodies; Theorems of Pappus and Guldinus.
[1] Chapters 8 and 9.

Weeks 7 and 8: Moments and products of inertia for areas, Composite areas and rigid body, Parallel-axis theorem, Moment of inertia of a rigid body about an arbitrary axis, Principal moments and principal axes of inertia.
[1] Chapter 10 (Sections 10.1 to 10.5) and Chapter 21 (Section 21.1).

Weeks 9 to 11: Conservative force fields, Conservation of mechanical energy, Work-energy equations, Kinetic energy and work-kinetic energy expressions based on center of mass, Moment of momentum equation for a single particle and a system of particles.
[2] Chapter 11 and Chapter 12 (Sections 12.5 and 12.6).

Weeks 12 to 14: Translation and rotation of rigid bodies, Chasles' theorem, General relationship between time derivatives of a vector for different references, Relationship between velocities of a particle for different references, Acceleration of particle for different references.
[2] Chapter 13 (Sections 13.1 to 13.3, and 13.6 to 13.8).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Know about the concepts in statics such as moments, couples, equilibrium in both two and three dimensions.	(i) Each topic to be explained with examples. (ii) Students to be involved in discussions and encouraged to ask questions. (iii) Students to be given homework/assignments. (iv) Students to be encouraged to give short presentations.	• Student presentations. • Participation in discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Understand the theory behind friction and center of gravity. Calculate moments of inertia of areas and rigid bodies.		
3.	Know about conservation of mechanical energy and work-energy equations.		
4.	Learn about translational and rotational motion of rigid bodies.		

Keywords: Center of gravity, Conservation of energy and its applications, Forces in equilibrium, Friction, Moments of inertia, Rigid body motion.

Acknowledgments

The following members were actively involved in drafting the LOCF syllabus of B.Sc. (Hons.) Mathematics, University of Delhi.

Head

- C.S. Lalitha, Department of Mathematics

Coordinator

- Hemant Kumar Singh, Department of Mathematics

Committee Members

- Satish Verma (SGTB Khalsa College)
- Preeti Dharmraha (Hansraj College)
- Monika Singh (LSR College for Women)
- Arun Pal Singh (Dyal Singh College)
- Raj Kumar (Kirori Mal College)
- Anita Bakshi (Vivekananda College)
- Shobha Rani (Vivekananda College)
- Manjari Srivastava (Miranda House)
- Swarn Singh (Sri Venkateswara College)
- Anju Nagpal (Vivekananda College)
- R.D. Sarma (Rajdhani College)
- Sanjay Mehra (Zakir Husain Delhi College)
- Vandana Rajpal (Shivaji College)
- Dhiraj Kumar Singh (Zakir Husain College)
- Arvind (Hansraj College)
- P.D. Sharma (SGTB Khalsa College)
- Aparna Jain (Shivaji College)
- Kriti Wadhwa (Hansraj College)
- Umesh (Rajdhani College)
- Vinay Trehan (Vivekananda College)
- Pankaj Garg (Rajdhani College)
- Virendrer Dalal (Ramjas College)
- Charanpreet Kaur (SGTB Khalsa College)

Patron

Dr.S. Venkata Kumar
Principal (Ag)
Sri Venkateswara College

Coordinators

Dr. N.Latha
Coordinator
Bioinformatics Centre
& Associate Professor
Department of Biochemistry
Sri Venkateswara College

Dr. Anita Verma
Associate Professor
Department of Zoology
Sri Venkateswara College

Dr. Mansi Verma
Assistant Professor
Department of Zoology
Sri Venkateswara College

For further details contact

cbc@svc.ac.in
9899916229
9891900122

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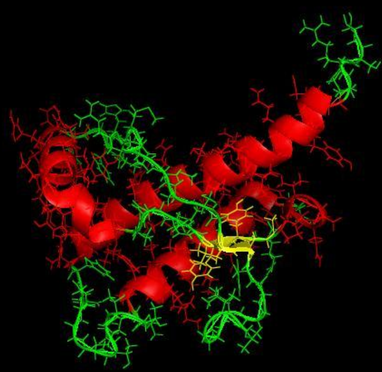
Biological Databases
Sequence Analysis
Phylogenetics
Molecular Modeling
Genomics
Computer Aided Drug Discovery
Biocomputing

Biology Meets Big Data

Sri Venkateswara College
(University of Delhi)
offers an add on course

CERTIFICATE PROGRAM IN BIOINFORMATICS & COMPUTATIONAL BIOLOGY (CBC)



LEARNING OUTCOMES

- To access, use and analyze public domain bioinformatics tools and softwares
- Learn to identify, compile, analyze, and communicate complex biological and genetic data for initiatives in areas such as human genome analysis, disease research, and drug discovery and development.

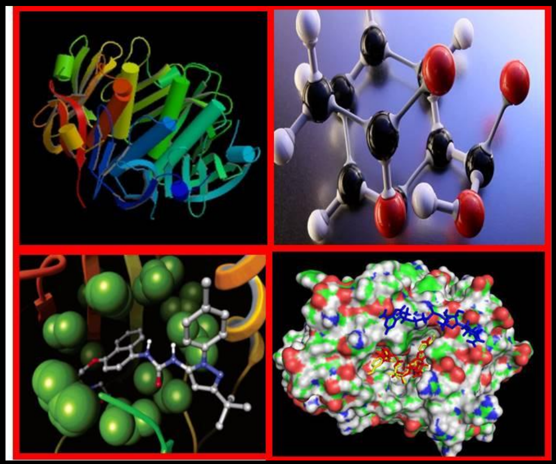
Build your Computational
&
Scientific skills

REGISTRATION DETAILS & FEE

COURSE FEE : Rs 3500

REGISTRATION

- Register online by September 10, 2020
- Applications available at www.svc.ac.in
- Payment can be done online using credit card/debit card by payment gateway



HIGHLIGHTS:

ELIGIBILITY

This course is open to all undergraduate students pursuing degree program in Biochemistry, Biological Sciences, Botany, Zoology , Biomedical Sciences, Biotechnology, Chemistry and Physics

COURSE DURATION

This course will be conducted on Saturdays and in holidays/ mid semester break. Program will run for 4 months in online mode (Sep to Dec)

HIGHLIGHTS

- Lectures and hands-on sessions by experts from both academia and industry
- Lectures by eminent speakers from DU, JNU, IIT Delhi, IIIT Delhi, TERI, CSIR-IGIB, NII, NIPGR and more.
- Certificates will be provided on successful completion of evaluation at the end of course.

NUMBER OF SEATS : 30
LIMITED SEATS
REGISTER NOW

THE COLLEGE DOES NOT TAKE RESPONSIBILITY FOR ADJUSTMENT OF DATES FOR CLASSES/EXAMINATION

Name of the paper	Type of paper	Name of the Coordinator	Name of Teacher Representative		
			1.	2.	3.
Basic Circuit Theory and Network Analysis	Core Course	Dr. Harsupreet Kaur	Dr. Sangeeta Shrivastava Rajdhani College	Dr. Neha Keshavmahavidyalaya College	Mr.Hari Singh Sri Venkateswara College
Mathematics Foundation for Electronics	Core Course	Professor E.K. Sharma	Dr. P. Arun SGTB Khalsa College	Dr. Shweta Gupta Bhaskaracharya College of Applied Sciences	Ms. Gauri Ghai Acharya Narendra Dev College
Electronic Circuit	Core Course	Dr. Harsupreet Kaur	Dr. Swati Nagpal Rajdhani College	Dr. Manoj Saxena Deen Dayal Upadhyaya College	Dr. Rakhi Narang Sri Venkateswara College
Digital Electronics and VHDL	Core Course	Professor Mridula Gupta	Dr. Preeti Singhal Rajdhani College	Dr. Anshu Rastogi Zakir Hussain College	Mr. Anil Sethi Keshavmahavidyalaya College
C Programming and Data Structure	Core Course	Mr. Amit Birwal	Dr. Anurag Mishra Deen Dayal Upadhyaya College	Dr. J. Lalitha Sri Venkateswara College	Dr. Ravneet Kaur Acharya Narendra Dev College
Microprocessors and Microcontrollers	Core Course	Professor Avinashi Kapoor	Dr. Amit Garg Acharya Narendra Dev College	Dr. Ravinder Kaur Deen Dayal Upadhyaya College	Dr. Praveen Pandey Maharaja Agrasen College
Electromagnetics	Core Course	Professor E.K. Sharma	Dr. Sunita Arya Rajdhani College	Dr.Jagneet Kaur Keshavmahavidyalaya College	Dr. Paramjeet Maharaja Agrasen College
Semiconductor Devices	Core Course	Dr. P. Koteswara Rao	Dr. P. K. Singh Hansraj College	Dr. Neeraj Tyagi Deen Dayal Upadhyaya College	Dr. Anju Aggarwal Acharya Narendra Dev College
Applied Physics	Core Course	Professor E.K. Sharma	Dr. P.Arun SGTB Khalsa College	Dr. Chhavi Bhatnagar Maharaja Agrasen College	Dr. Raghvendra S.Tomar Rajdhani College

Operational Amplifiers and Applications	Core Course	Dr. Harsupreet Kaur	Dr. Nutan Joshi Sri Venkateswara College	Dr. Mona Bhatnagar Hansraj College	Dr. Nirupama Kapoor SGTB Khalsa College
Signals and Systems	Core Course	Professor Avinashi Kapoor	Dr.Geetika Jain Saxena Maharaja Agrasen College	Dr. Amit Kumar Bhaskaracharya College of Applied Sciences	Dr. Chanchal Yadav Rajdhani College
Electronic Instrumentation	Core Course	Dr. Kamlesh Patel	Dr. Amit Pundir Maharaja Agrasen College	Dr. Avanish Mittal Bhaskaracharya College of Applied Sciences	Dr.Mamta Sharma Sri Aurobindo College
Communication Electronics	Core Course	Professor Mridula Gupta	Dr. Mamta Saini Hansraj College	Dr. Poonam Bedi SGTB Khalsa College	Dr. Vandana Bhalla Sri Aurobindo College
Photonics	Core Course	Professor E.K. Sharma	Dr. Sunita Jain Sri Venkateswara College	Dr. P. P. Singh Sri Aurobindo College	Dr. Geeta Mongia Bhaskaracharya College of Applied Sciences
Computer Networks	DSE	Mr. Amit Birwal	Dr. Anshu Rastogi Zakir Hussain College	Dr. Vandana Bhalla Sri Aurobindo College	Dr. Amita Kapoor Rajguru College of Applied Sciences
Electrical Machine	DSE	Professor Mridula Gupta	Dr. Swati Nagpal Rajdhani College	Dr. Amit Sehgal Hansraj College	Dr. Amit Kumar Bhaskaracharya College of Applied Sciences
Basic VLSI Design	DSE	Dr. Harsupreet Kaur	Dr. Sukhbinder Singh Rait Hansraj College	Dr. Sonia Ahlawat Rajguru College of Applied Sciences	Dr. Sachin Kumar Maharaja Agrasen College
Control System	DSE	Professor Mridula Gupta	Dr. Amit Sehgal Hansraj College	Dr. Monika Bhattacharya Keshavmahavidyalaya College	Mr. Puneet Sehgal ARSD College
Embedded Systems	DSE	Mr. Amit Birwal	Dr. Poonam Kasturi Deen Dayal Upadhyaya College	Dr. Praveen K Pandey Maharaja Agrasen College	Dr. Himanshu Kushwaha Keshavmahavidyalaya College

Transmission Line Wave Guide and Antenna Propagation	DSE	Professor E.K. Sharma	Dr. Ashwani Kumar Sri Aurobindo College	Dr. Paramjeet Maharaja Agrasen College	Dr. RInki Sharma Acharya Narendra Dev College
Numerical Techniques	DSE	Professor E.K. Sharma	Ms. Venika Gupta Rajguru College of Applied Sciences	Dr. Avaneesh Mittal Bhaskaracharya College of Applied Sciences	Ms. Shubhra Gupta Sri Venkateswara College
Digital Signal Processing	DSE	Professor Avinashi Kapoor	Dr. Naveen K. Jain Zakir Hussain College	Dr. Geetika J Saxena Maharaja Agrasen College	Dr. R.P. Risheshwar Sri Aurobindo College
Semiconductor Fabrication and Characterization	DSE	Dr. P. Koteswara Rao	Dr. J. Lalitha Sri Venkateswara College	Dr. P.K. Sisodia Zakir Hussain College	Dr. Sangeeta Shrivastava Rajdhani College
Power Electronics	DSE	Dr. P. Koteswara Rao	Dr. Neeru Kumar Sri Venkateswara College	Dr. Neelam Pahwa Zakir Hussain College	Dr. Nidhi Sinha SGTB Khalsa College
Modern Communication System	DSE	Professor Mridula Gupta	Dr. Natasha Maharaja Agrasen College	Dr. Mamta Saini Hansraj College	Dr. Jagneet Kaur Anand Keshavmahavidyalaya College
Design and Fabrication of PCB	SEC	Dr. P. Koteswara Rao	Dr. Neeraj Tyagi Deen Dayal Upadhyaya College	Mr. Prashant Kumar Keshavmahavidyalaya College	
Robotics	SEC	Mr. Amit Birwal	Mr. Manohar Singh Rajdhani College	Dr. Inderpreet Singh SGTB Khalsa College	Dr. Amita Kapoor Rajguru College of Applied Sciences
Mobile Application Development	SEC	Professor Mridula Gupta	Dr. Nisha Jha ARSD College	Ms. Neha Deen Dayal Upadhyaya College	Dr. Sachin Kumar Maharaja Agrasen College
Internet and JAVA Technologies	SEC	Mr. Amit Birwal	Dr. Amita Kapoor Rajguru College of Applied Sciences	Dr. Neha Verma Sri Venkateswara College	Mr. Arun Kumar ARSD College

Programming with Labview	SEC	Mr. Amit Birwal	Dr. Maneesha Maharaja Agrasen College	Dr.Jitender Kumar Bhaskaracharya College of Applied Sciences	Dr. Anita Kumari Acharya Narendra Dev College
Electronic Circuits and PCB Designing	GE	Dr. Harsupreet Kaur	Dr. Nutan Joshi Sri Venkateswara College	Ms. Aarti Malyan Bhaskaracharya College of Applied Sciences	Mr. Naveen Kumar Deen Dayal Upadhyaya College
Digital System Design	GE	Professor Mridula Gupta	Dr. Neha Keshavmahavidyalaya College	Dr. Shobhna Chandra Sri Aurobindo College	Ms. Swati Sharma SGTB Khalsa College
Instrumentation	GE	Dr. Kamlesh Patel	Dr. V.K. Sharma Keshavmahavidyalaya College	Dr. Shikha Madan Rajdhani College	Mr. Dharmendra Kumar Mahato Maharaja Agrasen College
Practical Electronics	GE	Mr. Amit Birwal	Dr. Preeti Singhal Rajdhani College	Dr. Inderbir Kaur Bhaskaracharya College of Applied Sciences	Dr.Amit Jain Rajdhani College
Communication Systems	GE	Professor Mridula Gupta	Dr. Neeru Kumar Sri Venkateswara College	Mr. Anil Sethi Keshavmahavidyalaya College	Ms. Gauri Ghai Acharya Narendra Dev College
Microprocessor and Microcontroller	GE	Professor Avinashi Kapoor	Dr. Jyoti Anand Keshavmahavidyalaya College	Dr.Jitender Kumar Bhaskaracharya College of Applied Sciences	Dr. Manju Pruthi Sri Aurobindo College
Consumer Electronics	GE	Professor Mridula Gupta	Dr. Meena Dadu ARSD College	Dr. Mamta Sharma Sri Aurobindo College	Ms. Surbhi Aggarwal Sri Aurobindo College

FACULTY: Dr. Kalyani Krishna, Dr. Abhishek Chandra, Dr. Pooja Gokhale Sinha and Dr. Sunita Yadav

DEPARTMENT: Botany/ Environmental Sciences

NAME OF THE ACTIVITY: Add-on Course on Climate change: Issues, concerns and strategies; First Batch			
DATE	**FACULTY**	**DEPARTMENT/COMMITTEE**	**COORDINATOR NAME**
09th February, 2019 – 7th April, 2019	Dr. Kalyani Krishna Dr. Abhishek Chandra Dr. Pooja Gokhale Dr. Sunita Yadav	Botany Environmental Sciences	Dr. Kalyani Krishna Dr. Abhishek Chandra
TIME	**VENUE**	**NUMBER OF PARTICIPANTS**	**NATURE: Outdoor/Indoor**
s	Sri Venkateswara College	45	Indoor
SUPPORT/ASSISTANCE:			

BRIEF INFORMATION ABOUT THE ACTIVITY (**CRITERION NO. – 3 and 7**):

TOPIC/SUBJECT OF THE ACTIVITY	Climate Change
OBJECTIVES	To make the participants aware about the issue of climate change
METHODOLOGY	Resource persons were invited to deliver modules on different topics related to climate change
OUTCOMES	45 participants successfully completed the course and were awarded the certificate of completion

PROOFS & DOCUMENTS ATTACHED (Tick mark the proofs attached):

Notice &Letters	**Student list of participation**	**Activity report**	**Photos**	Feedback form
Feedback analysis	News clip with details	Certificate	Any other	

IQAC Document No:	Criterion No:	Metric No:
Departmental file no	IQAC file No;	

NAME OF TEACHER & SIGNATURE	NAME OF HEAD/ COMMITTEE INCHARGE & SIGNATURE	IQAC COORDINATOR (SEAL & SIGNATURE)

For Reference

Criterion I	Curricular Aspects (planning &Implementation)		Criterion V	Student Support & Progression
Criterion II	Teaching Learning & Evaluation		Criterion VI	Governance
Criterion III	Research, Innovations & Extension		Criterion VII	Institutional Values & Best Practices
Criterion IV	Learning Resources and Infrastructure			

Summary Report

Add on course (Climate change)

Departments of Botany and Environmental Science organized an add-on course on "Climate Change: Issues, Concerns and Strategies". The course conveners were Dr. Kalyani Krishna and Dr. Abhishek Chandra and the course coordinators were Dr Pooja Gokhale Sinha and Dr Sunita Yadav.

The first batch of the course commenced from 09 February 2019. The opening remarks for the program were given by course conveners followed by interaction with participants. The inauguration was done by Prof. K S Rao, Course Mentor, Department of Botany, University of Delhi, who acquainted the participants with the need for concern towards climate change. It was followed by a lecture on “An introduction to Climate” by Prof. Devesh K Sinha, Department of Geology, University of Delhi. The lecture was very engaging, interactive and well-explained with the help of visual tools, such as presentations. The participants were given an introduction to various climatic events and factors that affect the world climatic regions.

The second module of the course was conducted on 16 February 2019 which consisted of two lectures. First one titled “Adaptation and Mitigation strategies for combating climate change: Carbon capture and storage by biotic and abiotic strategies” was delivered by Prof K G Saxena, School of Environmental Sciences, JNU, New Delhi 110067, followed by a lecture on " Climate change impacts on earth system: temperature rise in atmosphere, water and soil, global carbon cycling”" delivered by Dr T. Shimrah,. University School of Environment Management, GGS Indraprastha University, Dwarka 16C, New Delhi.

The third module of the course was conducted on 23 February 2019 that included a lecture on "Climate change impacts on earth atmosphere; The past and the future roadmaps of GHGs Inventories" by Prof. C P Kaushik, Professor Emeritus, Amity School of Earth and Environmental Sciences, Amity University, Haryana, Gurgaon; and Retd. Professor, Department of Environmental Science & Technology, Guru Jambeshwar University of Science & Technology, Hisar, Haryana. followed by a talk on "Applications of Remote Sensing to Climate Change Studies and Research" delivered by Prof. Kiranmay Sarma. University School of Environment Management, GGS Indraprastha University, Dwarka 16C, New Delhi.

The fourth module of the course was held on 02 Match 2019 with lecture on "Soil and Climate Change: Soil Organic Carbon Unlocking the Potential to a climate Change " delivered by Dr. Abhishek Chandra, Assistant Professor, Sri Venkateswara College, University of Delhi, New

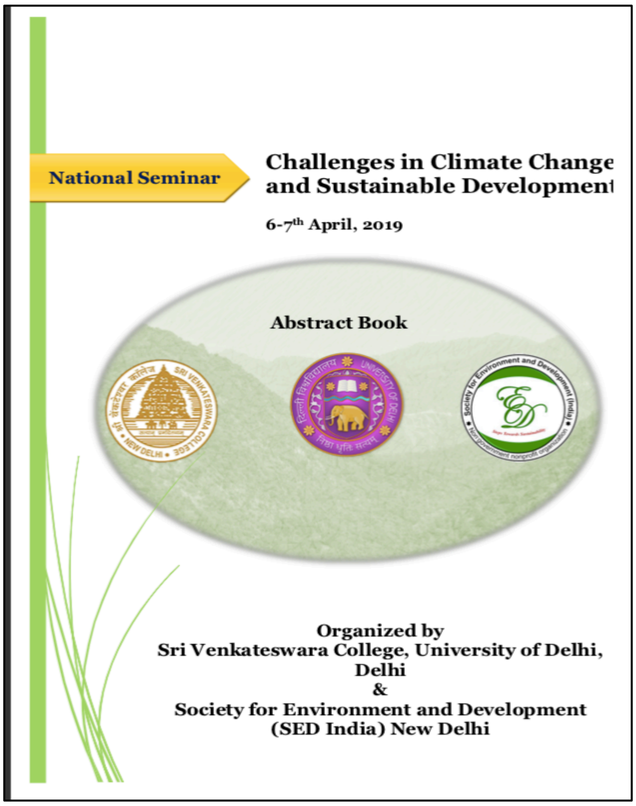
Delhi, followed by another lecture on Climate Change Impacts on Agriculture, delivered by Dr. D C Upreti, Retd. Principal Scientist, Department of Plant Physiology, IARI, New Delhi.

The fifth module of the course was conducted on 09 March 2019, where an interactive lecture on Climate change policies and regulations: Earth's summit, Montreal protocol, WMO; UNEP; UNFCCC, IPCC, COPs by Dr. S D Attri, Dy. Director, India Metrological Department (IMD), New Delhi was followed by a lecture on "Climate change: Planet earth's climate system: Past, Present and Future"by Dr Ashutosh Singh, Assistant Professor, Department of Geology, University of Delhi.

The Sixth module of the course was conducted on 16 Match 2019 that included a lecture on "Climate change impacts on earth atmosphere; The past and the future roadmaps of GHGs Inventories" by Prof. C P Kaushik, Professor Emeritus, Amity School of Earth and Environmental Sciences, Amity University, Haryana, Gurgaon,and Retd. Professor, Department of Environmental Science & Technology, Guru Jambeshwar University of Science & Technology, Hisar, Haryana. succeeded by another lecture on "Sustainable Development and climate change in the Himalayas" Dr. Mustafa Ali Khan, Indian Himalayas Climate Adaptation Programme (IHCAP) Embassy of Switzerland, Swiss Cooperation Office India, Nyaya Marg, Chanakyapuri, New Delhi.

The course was concluded on 30 Match 2019 by an interactive lecture on ways to tackle climate change by Dr. Kalyani Krishna, course coordinator, Department of Botany, Sri Venkateswara College. It was followed by getting feedback forms and carbon footprint forms from the participants.
The course was completed by an assessment conducted on 30 Match 2019, upon successful submission of which, the participants were awarded completion certificates for the add-on course.

The first batch of add on course Climate Change 2019 concluded with National Seminar on Challenges in Climate Change and Sustainable Development on 6-7 April 2019. There was a valedictory lecture On the topic of "Climate Change and Human Wellbeing" delivered by Prof. K S Rao (Course Mentor), Department of Botany, University of Delhi. It was followed by distribution of certificates.



The course was well-structured and gave the participants an insight to concerns related to climate change and strategies to tackle it. It was highly insightful and was aimed to help the participants in understanding their responsibilities towards nature.

Document -1

List of successful participants :

SR NO	Name of Participants
1	Aashi Singh
2	Aastha Saini
3	Abhimanyu Singh
4	Ajita Mishra
5	akanksha aggarwal
6	Anand Prakash Bedgujar
7	Anju Malik
8	Ankita Saha
9	Aparna Pillai
10	APOORVA SODHI
11	Arti Dandriyal
12	Asha
13	Ashlesha Manta
14	DEEPAK KUMAR JHA
15	Devangi Mritunjay
16	Esha Dua
17	Israt Jahan
18	Kanika Chawla
19	Kriti arya
20	Kumari Priyanka
21	Mahima
22	Manpreet Kaur
23	Mithlesh kumari yadav
24	MOHIT Gupta
25	MOKAM LALITH KRISHNA YADAV
26	Muskaan Biradar

27	Muskaan Khanna
28	Nabanita Ghosh
29	Neelam
30	Oass Yaduvanshi
31	Osheen Taneja
32	Priyanshi Narula
33	Rashi sehra
34	Saadan hussain
35	Saurabh Chauhan
36	**SNEH SMITA**
37	Stuti Kumari
38	SUCHITA
39	Swapnil
40	Swostik Preetam Padhy
41	Tushadri Singh
42	Vaishali
43	VAISHALI GUPTA
44	Vanisha
45	Vanshika Chaubey

Document -1

SRI VENKATESWARA COLLEGE
(University of Delhi)

Internal Quality Assurance Cell

This is to certify that the Activity report (Teacher/Department /Society/Association) has been submitted for documentation to IQAC, Sri Venkateswara College, University of Delhi.

N. Latha
IQAC Coordinator
Sri Venkateswara College

Coordinator, IQAC
Sri Venkateswara College
(University of Delhi)
Dhaula Kuan, New Delhi-110021

C. Sheela Reddy
PRINCIPAL
Sri Venkateswara College

PRINCIPAL
Sri Venkateswara College
(University of Delhi)
Dhaula Kuan, New Delhi-110021

दिल्ली विश्वविद्यालय
UNIVERSITY OF DELHI

Bachelor of Science (Honours) Physics

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Date:	**Academic Council**	No:
Date:	**Executive Council**	No:

Applicable for students registered with Regular Colleges.

List of Contents

Preamble

Higher Education in India is in need of reform. On the one hand, while there is a need for increased access to higher education in the country, it is also necessary to improve the quality of higher education. New initiatives and sustained efforts are needed to develop and enhance the spirit of enquiry, analytical ability and comprehension skills of the young generation of students. An emerging knowledge based society requires that they are able to acquire and generate new knowledge and skills, and can creatively apply them to excel in their chosen vocations. Our higher education system needs to inculcate exemplary citizenship qualities and motivate students to contribute to the society at large. Such abilities and qualities of our youth will be crucial for the country to face the challenges of the future.

One of the reforms in undergraduate (UG) education, initiated by the University Grants Commission (UGC) at the national level in 2018, is to introduce the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student-centric, interactive and outcome-oriented with well- defined aims and objectives.

The Department of Physics and Astrophysics, University of Delhi took up the task of drafting the LOCF for UG Physics courses according to guidelines sent in March 2019 by the Undergraduate Curriculum Review Committee (UGCRC)-2019 of the University of Delhi. The Committee of Courses of the Department constituted a Steering Committee, whose composition is given in Annexure 1A, to plan and formulate the LOCF for UG Physics courses of the University. The Steering Committee formed Subject Working Groups (Annexure 1B) to formulate the content of different sets of courses. The Subject Working Groups included teachers from more than twenty colleges of the University, who have experience of teaching the respective courses. About eighty faculty members from the Department of Physics and Astrophysics and Physics Departments of colleges of the University have contributed to this important task. The inputs of the Subject Working Groups were compiled, and the present document prepared by a final drafting team (Annexure 1C).

The University of Delhi offers the undergraduate B.Sc. (Honours) Physics programme, the B.Sc. Physical Sciences programme with Physics and Electronics disciplines, as well as general elective courses in Physics for students of Honours programmes in disciplines other than Physics. The LOCF has been prepared for all of the above.

An earlier draft of the LOCF of the University of Delhi was put in the public domain for stakeholders' comments in May 2019. This was a revised version of the existing Choice Based Credit System (CBCS) undergraduate programme at the University of Delhi. We thank the stakeholders who took time and made effort to give us feedback on the earlier draft. Many of the comments received have helped us improve the LOCF draft.

We acknowledge the use of the document "Learning Outcomes based Curriculum Framework (LOCF) for Undergraduate Programme B.Sc. (Physics) 2019" put up by the UGC on its website in May 2019 (https://www.ugc.ac.in/pdfnews/1884134_LOCF-Final_Physics-report.pdf) and prepared by its Subject Expert Committee for Physics. This document has helped in clarifying the features of the LOCF and is the original source of a significant part of the text of the present document.

Keywords

Core Courses (CC)

Course Learning Outcomes (CLO)

Ability Enhancement Compulsory Course (AECC)

Discipline Specific Electives (DSE)

Generic Electives (GE)

Learning Outcome-based Curriculum Framework (LOCF)

Programme Learning Outcomes

Skill Enhancement Courses (SEC)

Student Centric

Teaching Learning Processes

Learning Outcomes-Based Curriculum Framework for Undergraduate Education in Physics

1. INTRODUCTION

The learning outcomes-based curriculum framework for a degree in B.Sc. (Honours) Physics is intended to provide a comprehensive foundation to the subject, and to help students develop the ability to successfully continue with further studies and research in the subject. The framework is designed to equip students with valuable cognitive abilities and skills so that they are successful in meeting diverse needs of professional careers in a developing and knowledge-based society. The curriculum framework takes into account the need to maintain globally competitive standards of achievement in term of the knowledge and skills in Physics, as well develop scientific orientation, enquiring spirit, problem solving skills and values which foster rational and critical thinking.

Due to the large diversity in India, a central university like the University of Delhi gets students from very different academic backgrounds, regions and language zones. While maintaining high standards, the learning outcome-based curriculum provides enough flexibility to teachers and colleges to respond to diverse needs of students.

The learning outcome-based curriculum framework for undergraduate courses in Physics also allows for flexibility and innovation in the programme design to adopt latest teaching and assessment methods and include introduction to new areas of knowledge in the fast-evolving subject domains. The process of learning is defined by the following steps which form the basis of final assessment of the achievement at the end of the program.

(i) Development of an understanding and knowledge of basic Physics. This involves exposure to basics facts of nature discovered by Physics through observations and experiments. The other core component of this development is introduction to physics concepts and principles, their theoretical relationships in laws of Physics, and deepening of their understanding via appropriate problems.

(ii) The ability to use this knowledge to analyze new situations and learn skills and tools like laboratory techniques, computational methods, and applied mathematics to find solution, interpret results and make meaningful predictions.

(iii) The ability to synthesize the acquired knowledge and experience for an improved comprehension of the physical problems and to create new skills and tools for their possible solutions.

2.LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK FOR PROGRAMME IN B.SC. (HONS.) PHYSICS

2.1 NATURE AND EXTENT OF THE PROGRAMME IN B.SC. (HONS.) PHYSICS

The B.Sc. (Hons.) Physics programme builds on the basic Physics taught at the +2 level in all the schools in the country. Ideally, the +2 senior secondary school education should aim and achieve a sound grounding in understanding the basic Physics with sufficient content of topics from modern Physics and contemporary areas of exciting developments in physical sciences. The curricula and syllabi should be framed and implemented in such a way that the basic connection between theory and experiment and its importance in understanding Physics is made clear to students. This is very critical in developing a scientific temperament and the urge to learn and innovate in Physics and other sciences. Unfortunately the condition of our school system in most parts of the country lacks the facilities to achieve the above goal, and it is incumbent upon the college/university system to fill gaps in the scientific knowledge and understanding of our country's youth who complete school curricula and enter university education.
Physics is an experimental and theoretical science that studies systematically the laws of nature operating at length scales from the sub-atomic domains to the entire universe. The scope of Physics as a subject is very broad. The core areas of study within the disciplinary/subject area of the B.Sc. (Hons.) Physics programme are: Classical and Quantum Mechanics, Electricity and Magnetism, Thermal and Statistical Physics, Wave theory and Optics, Physics of the Materials, Digital Electronics, and specialized methods of Mathematical Physics and their applications in different branches of the subject. Along with the theoretical course work students also learn physics laboratory methods for different branches of physics, specialized measurement techniques, analysis of observational data, including error estimation, and scientific report writing. The latest addition to Physics pedagogy incorporated in the LOCF framework is computational physics, which involves adaptation of Physics problems for algorithmic solutions, and modelling and simulation of physical phenomenon. The elective modules of the framework offer students choice to gain knowledge and expertise in more specialized domains of Physics like Nuclear and Particle physics, Nanophysics, Astronomy and Astrophysics, etc. and interdisciplinary subject areas like Biophysics, Geophysics, Environmental Physics, Medical Physics, etc.

The physics-based knowledge and skills learnt by students also equip them to be successful in careers other than research and teaching in Physics.

2.2 AIMS OF BACHELOR'S DEGREE PROGRAMME IN B.SC. (HONS.) PHYSICS

The LOCF based UG educational program in Physics aims to

- create the facilities and learning environment in educational institutions to consolidate the knowledge acquired at +2 level, motivate students to develop a deep interest in Physics, and to gain a broad and balanced knowledge and understanding of physical concepts, principles and theories of Physics.

- provide opportunities to students to learn, design and perform experiments in lab, gain an understanding of laboratory methods, analysis of observational data and report writing, and acquire a deeper understanding of concepts, principles and theories learned in the classroom through laboratory demonstration, and computational problems and modelling.
- develop the ability in students to apply the knowledge and skills they have acquired to get to the solutions of specific theoretical and applied problems in Physics.
- to prepare students for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas, as Physics is among the most important branches of science necessary for interdisciplinary and multidisciplinary research.
- to prepare students for developing new industrial technologies and theoretical tools for applications in diverse branches of the economic life of the country, as Physics is one of the branches of science which contribute directly to technological development; and it has the most advanced theoretical structure to make quantitative assessments and predictions, and
- in light of all of the above to provide students with the knowledge and skill base that would enable them to undertake further studies in Physics and related areas, or in interdisciplinary/multidisciplinary areas, or join and be successful in diverse professional streams including entrepreneurship.

3. GRADUATE ATTRIBUTES FOR B.SC. (HONS.) PHYSICS

Some of the characteristic attributes of a graduate in Physics are

- **Disciplinary knowledge**

(i) Comprehensive knowledge and understanding of major concepts, theoretical principles and experimental findings in core areas of Physics -like Classical and Quantum mechanics, Thermodynamics and Statistical mechanics, Electricity, Magnetism and Electromagnetic theory, Wave Theory, Optics, Solid State Physics, and Analogue and Digital electronics; and in the chosen disciplinary elective sub field of the subject like Nuclear and Particle Physics, Analytical dynamics, Astronomy and Astrophysics , Advanced Mathematical Physics, Nanophysics and interdisciplinary subfields like Biophysics, Geophysics, Atmospheric Physics, Medical Physics, Embedded Systems, etc..

(ii) Ability to use physics laboratory methods and modern instrumentation for designing and implementing new experiments in physics, interdisciplinary/multidisciplinary research areas and industrial research.

- **Skilled communicator:** Ability to transmit abstract concepts and complex information relating to all areas in Physics in a clear and concise manner through scientific report writing. Ability to express complex relationships and information through graphical methods and proper tabulation. Ability to explain complex processes through simulation and modelling. Ability to express complex and technical concepts orally in a simple, precise and straightforward language for better understanding.
- **Critical thinking:** Ability to distinguish between relevant and irrelevant facts and information, discriminate between objective and biased information, apply logic to arrive at definitive conclusions, find out if conclusions are based upon sufficient

evidence, derive correct quantitative results, make rational evaluations, and arrive at qualitative judgments according to established rules.

- **Sense of inquiry:** Capability for asking relevant/appropriate questions relating to the issues and problems in the field of Physics. Planning, executing and reporting the results of theoretical or experimental investigation.
- **Team player/worker**: Capable of working effectively in diverse teams in both classroom, laboratory, Physics workshop and in field-based situation.
- **Skilled project manager:** Capable of identifying/mobilizing appropriate resources required for a project, and managing a project through to completion, while observing responsible and ethical scientific conduct, safety and laboratory hygiene regulations and practices.
- **Digitally Efficient***:* Capable of using computers for computational and simulation studies in Physics. Proficiency in appropriate software for numerical and statistical analysis of data, accessing and using modern e-library search tools, ability to locate, retrieve, and evaluate Physics information from renowned physics archives, proficiency in accessing observational and experimental data made available by renowned research labs for further analysis.
- **Ethical awareness/analytical reasoning***:* The graduates should be capable of demonstrating the ability to think and analyze rationally with modern and scientific outlook and adopt unbiased objectives and truthful actions in all aspects of work. They should be capable of identifying ethical issues related to their work. They should be ready to appropriately acknowledge direct and indirect contributions received from all sources, including from other personnel in the field of their work. They should be willing to contribute to the free development of knowledge in all forms. Further, unethical behavior such as fabrication, falsification or misrepresentation of data, or committing plagiarism, or not adhering to intellectual property rights should be avoided.
- **Social, National and International perspective:** The graduates should be able to develop a perspective about the significance of their knowledge and skills for social well-being. They should have a national as well as an international perspective about their work and career in the chosen field of academic and research activities.
- **Lifelong learners:** Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and reskilling in all areas of Physics.

4. QUALIFICATION DESCRIPTORS FOR GRADUATES IN B.Sc. (HONS.) PHYSICS

The qualification descriptor for B.Sc. (Hons.) Physics graduates include the following: They should be able to:

- Demonstrate

(i) a systematic and coherent understanding of basic Physics including the concepts, theories and relevant experimental techniques in the domains of Mechanics, Electricity and Magnetism, Waves and Optics, Thermal Physics, Quantum Mechanics, Statistical Mechanics, Mathematical Physics and their applications in other areas of Physics;

(ii) the ability to relate their understanding of physics to other sciences and hence orient their knowledge and work towards multi-disciplinary/inter-disciplinary contexts and problems;

(iii) procedural knowledge that creates different types of professionals related to different areas of study in Physics and multi/interdisciplinary domains, including research and development, teaching, technology professions, and government and public service;

(iv) skills in areas of specializations of their elective subfields so that they can continue with higher studies and can relate their knowledge to current developments in those subfields.

- Use knowledge, understanding and skills required for identifying problems and issues relating to Physics, and its interface with other subjects studied in the course; collect relevant quantitative and/or qualitative data from a wide range of sources including various research laboratories of the world, and do analysis and evaluation using appropriate methodologies..

- Use knowledge, understanding and skills required for identifying problems and issues relating to Physics, and its interface with other subjects studied in the course; collect relevant quantitative and/or qualitative data from a wide range of sources from various research laboratories of the world, their application, analysis and evaluation using appropriate methodologies..

- Communicate the results of studies undertaken accurately in a range of different contexts using the main concepts, constructs and techniques of Physics and other subjects studied in the course. Develop communication abilities to present these results in technical as well as popular science meetings.

- Ability to meet their own learning needs, drawing on a range of pedagogic material available on the internet and books, current research and development work and professional materials, and in interaction with other science professionals.

- Apply their knowledge of Physics (theoretical and laboratory skills) to new/unfamiliar contexts to identify and analyze problems and issues, solve complex problems in Physics and its interface with other subjects.

- Demonstrate Physics-related technological skills that are relevant to Physics-related trades and employment opportunities.

5. PROGRAMME LEARNING OUTCOMES IN B.Sc. (HONS.) PHYSICS

Students graduating with the B.Sc. (Honours) Physics degree should be able to

- Acquire
  - (i) a fundamental/systematic and coherent understanding of the academic field of basic Physics in areas like Mechanics, Electricity and Magnetism, Waves and Optics, Thermal and Statistical Physics, Quantum Mechanics, Mathematical Physics and their applications to other core subjects in Physics;
  - (ii) a wide ranging and comprehensive experience in physics laboratory methods in experiments related to mechanics, optics, thermal physics, electricity, magnetism, digital electronics, solid state physics and modern physics. Students should acquire the ability for systematic observations, use of scientific research instruments, analysis of observational data, making suitable error estimates and scientific report writing.
  - (iii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in research and development, teaching and government/public service;
  - (iv) Knowledge and skills in areas related to their specialization area corresponding to elective subjects within the disciplinary/subject area of Physics and current and emerging developments in the field of Physics.

- Demonstrate the ability to use skills in Physics and its related areas of technology for formulating and tackling Physics-related problems and identifying and applying appropriate physical principles and methodologies to solve a wide range of problems associated with Physics.
- Recognize the importance of mathematical modelling simulation and computational physics, and the role of approximation and mathematical approaches to describing the physical world.
- Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories of Physics.
- Demonstrate relevant generic skills and global competencies such as
  - (i) problem-solving skills that are required to solve different types of Physics-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary area boundaries;
  - (ii) Investigative skills, including skills of independent investigation of Physics-related issues and problems;
  - (iii) Communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;
  - (iv) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Physics and ability to translate them with popular language when needed;
  - (v) ICT skills;
  - (vi) Personal skills such as the ability to work both independently and in a group.
- Demonstrate professional behavior such as

(i) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism;
(ii) the ability to identify the potential ethical issues in work-related situations;
(iii) be committed to the free development of scientific knowledge and appreciate its universal appeal for the entire humanity;
(iii) appreciation of intellectual property, environmental and sustainability issues;
(iv) promoting safe learning and working environment.

6. TEACHING LEARNING PROCESSES

The teaching learning processes play the most important role in achieving the desired aims and objectives of the undergraduate programs in Physics. The LOCF framework emphasizes learning outcomes for every physics course and its parts. This helps in identifying most suitable teaching learning processes for every segment of the curricula. Physics is basically an experimental science with a very elaborate and advanced theoretical structure. Systematic observations of controlled experiments open up windows to hidden properties and laws of nature. Physics concepts and theories are meant to create a systematic understanding of these properties and laws. All principles and laws of physics are accepted only after their verifications and confirmations in laboratory, or observations in the real world, which require scientists trained in appropriate experimental techniques, and engineers to design and make advanced scientific instruments. Physics graduates need a deep understanding of physics concepts, principles and theories, which require familiarity with different branches of mathematical physics. To achieve these goals, the appropriate training of young individuals to become competent scientists, researchers and engineers in future has to be accomplished. For this purpose a very good undergraduate program in Physics is required as a first step. An appropriate teaching-learning procedural protocol for all the colleges is therefore essential. To be specific, it is desirable to have:
Sufficient number of teachers in permanent position to do all the class room teaching and supervise the laboratory experiments to be performed by the students.

- All teachers should be qualified as per the UGC norms and should have good communication skills.
- Sufficient number of technical and other support staff to run the laboratories, libraries, equipment and maintain the infrastructural facilities like buildings, ICT infrastructure, electricity, sanitation, etc.
- Necessary and sufficient infrastructural facilities for the class rooms, laboratories and libraries.
- Modern and updated laboratory equipment needed for the undergraduate laboratories and reference and text books for the libraries.
- Sufficient infrastructure for ICT and other facilities needed for technology-enabled learning like computer facilities, PCs, laptops, Wi-Fi and internet facilities with all the necessary software.

Teachers should make use of all the approaches for an efficient teaching-learning process, i.e.:

(i) Class room teaching with lectures using traditional as well as electronic boards.

(ii) Demonstration of the required experiments in laboratory and seesions on necessary apparatuses, data analysis, error estimation and scientific report writing for effective and efficient learning of laboratory techniques.

(iii) Imparting a problem solving ability which enables a student to apply physical and mathematical concepts to a new and concrete situation is essential to all courses. This can be accomplished through examples discussed in the class or laboratory, assignments and tutorials.

(iv) CBCS curriculum has introduced a significant content of computational courses. Computational physics should be used as a new element in the physics pedagogy, and efforts should be made to introduce computational problems, including simulation and modelling, in all courses.

(v) Teaching should be complimented with students seminar to be organized very frequently.

(vi) Guest lectures and seminars should be arranged by inviting eminent teachers, and scientists.

(vii) Open-ended project work should be given to all students individually, or in group to 2-3 students depending upon the nature of the course.

(viii) Since actual UG program teaching is done in affiliated colleges which have differing levels of infrastructure and student requirements, the University department should organize regular workshops for college faculty on latest laboratory equipment and experiments, and computational physics software for achieving uniform standards.

(ix) Internship of duration varying from one week anytime in the semester, and/or 2-6 weeks during semester break and summer breaks should be arranged by the college for the students to visit other colleges/universities/HEI and industrial organizations in the vicinity. If needed, financial assistance may also be provided for such arrangements.

(x) Special attempts should be made by the institution to develop problem-solving skills and design of laboratory experiments for demonstration at the UG level. For this purpose a mentor system may be evolved where 3-4 students may be assigned to each faculty member.

(xi) Teaching load should be managed such that the teachers have enough time to interact with the students to encourage an interactive/participative learning.

A student completing the Physics Hons course under the CBCS takes 14 core courses, 4 discipline specific elective (DSE) courses, 4 general elective (GE) courses, two skill enhancement courses (SEC) and two ability enhancement compulsory courses (AECC). Since different categories of courses have different objectives and intended learning outcomes, the most efficient and appropriate teaching learning processes would not be same for all categories of courses.

6.1 TEACHING LEARNING PROCESSES FOR CORE COURSES

The objective of Core courses is to build a comprehensive foundation of physics concepts, principles and laboratory skills so that a student is able to proceed to any specialized branch. Rather than a quantitative amalgamation of disparate knowledge, it is much more preferable that students gain the depth of understanding and ability to apply what they have learnt to diverse problems. Problem solving should be integrated into the teaching of core courses and proportionally more time should be spent on it. It is advisable that a list of problems is distributed to students before the discussion of every topic, and they encouraged to solve these in the self-learning mode, since teachers are unlikely to get time to discuss all of them in the class room. Under the current CBCS system the teaching of core courses suffers from a serious lacuna. A structural reform under CBCS system to allow for tutorial sessions to accompany the core course would greatly facilitate these courses.

In the first year students are fresh from school. Given the diversity of their backgrounds, and the lack of adequate infrastructure and training in the school science learning, special care and teacher attention is essential in the first year. Mentorship with senior students and teachers can help them ease into rigorous of university level undergraduate learning. It is also the time when many students get their first proper exposer to physics laboratory work. Demonstration on the working of required apparatuses should be given in few beginning labs. Sessions on experimental data analysis, error estimation, and scientific report writing are crucial in the first year physics laboratory teaching. Once a good foundation for the experimental physics is created in the first year, then students can work on their own in subsequent labs, and also get motivated to explore experimental physics projects outside their curricula.

Many students get their first exposure to computers as a working tool (rather than a means of communication and entertainment) in computational lab courses. A great degree of hand holding is necessary during first computational physics courses. Since computational work can easily be done outside the designated laboratory hours, mentor ship can be very useful in helping students become comfortable with computers. Colleges should try that students from weaker economic backgrounds especially have adequate access to computers.

6.2 TEACHING LEARNING PROCESSES FOR DISCIPLINE SPECIFIC ELECTIVES

The objective of DSE papers is to expose students to domain specific branches of physics and prepare them for further studies in the chosen field. While students must learn basic theoretical concepts and principles of the chosen domain, a sufficient width of exposure to diverse topics is essential in these papers. Student seminars and projects can be a very fruitful way to introduce students to the latest research level developments. Students should be encouraged to use their computational physics skills to work on publicly available observational data put out by many research labs and observatories worldwide.

6.3 TEACHING LEARNING PROCESSES FOR SKILL ENHANCEMENT COURSES

Skill Enhancement papers are intended to help students develop skills which may or may not be directly applicable to physics learning. These courses introduce an element of diversity of learning environments and expectations. Efforts should be made that students gain adequate ‘hands-down’ experience in the desired skills. The theory parts of these courses are intended to help students get prepared for such experiences. Since the assessment of these courses is largely college based, teachers should make full use of it to design novel projects.

6.4 TEACHING LEARNING PROCESSES FOR GENERIC ELECTIVES

Physics GE papers are taken by students of other honours courses. Most of these students would have studied physics at the school level, so these courses are not meant to be introductory. However, the teaching of these courses should be oriented to expose the non-physics students to the wonders of physics. Basic level projects that focus on real life applications of physics can be a useful means to generate student interest and motivate them for self-study.

At the end, the main purpose of Physics teaching should be to impart higher level objective knowledge to students in concrete, comprehensive and effective ways. Here, effectiveness implies gaining knowledge and skill which can be applied to solve practical problems as well as attaining the capability of logical thinking and imagination which are necessary for the creation of new knowledge and new discoveries. Once the students understand 'why is it worth learning?' and 'how does it connect to the real world?', they will embrace the curriculum in a way that would spark their imagination and instill a spirit of enquiry in them, so that in future they can opt for further investigations or research. All in all, the teacher should act as a facilitator and guide and not as a guardian of the curriculum.

7. ASSESSMENT METHODS

In the undergraduate education of Physics leading to the B.Sc. (Honours) Physics degree, the assessment and evaluation methods should focus on testing the conceptual understanding of basic concepts and theories, experimental techniques, development of mathematical skills, and the ability to apply the knowledge acquired to solve new problems and communicate the results and findings effectively.

The two perennial shortfalls of the traditional science examination process in our country are the reliance on rote learning for written exams, and a very perfunctory evaluation of laboratory skills. Greater emphasis on problem solving and less importance to textbook derivations discourages rote learning. Theory examinations should be based primarily on unseen problems. Continuous evaluation of students' work in the laboratory, and testing them on extensions of experiments they have already performed can give a more faithful evaluation of their laboratory skills.

Needless to say, there should be a continuous evaluation system for the students. This will enable teachers not only to ascertain the overall progress of learning by the students, but also to identify students who are slow learners and for whom special care should be taken. An appropriate grading system is the 'relative grading system'. It introduces a competitive element among students, but does not excessively penalizes weaker students.

Since the Learning Objectives are defined clearly for each course in the LOCF framework, it is easier to design methods to monitor the progress in achieving the learning objectives during the course and test the level of achievement at the end of the course.

- The courses offered in the undergraduate Physics are the first courses at the college/university level. Formative Assessment for monitoring the progress towards achieving the learning objectives is an important assessment component, which provides both teachers and students feedback on progress towards learning goals. University of Delhi examination system has 20 percent internal assessment for theory component, and 50 percent for laboratory components. These marks should be distributed in periodic assessments in different modes to serve the intended purpose. Some of the possible methods for the theory component of Formative Assessment are i) periodic class tests, ii) Regular problem based assignments, iii) unannounced short quizzes iv) individual seminar presentations v) longer assignments for covering theory and derivations not discussed in regular lectures vi) True/False Tests vii) Multiple Choice Tests for large classes viii) Any other innovative tests in the context of the course.

- To help students prepare themselves for formative assessment, and to motivate them for self-learning, it is advisable that a Model Problem Set is made available to them in the beginning of the course, or problem sets are given before discussion of specific topics in class
- In preparing students for Substantive Summative Assessment at the end of the semester it is helpful if a Model/mock question paper is made available to them in the beginning of the course.

Formative assessment for laboratory work may include) Regular evaluation of experiments regarding a) written report of each experiment b) Viva-Voce on each experiment ii) Test through setting experiments by assembling components iii) written test on experiments done in the lab and data analysis, iv) Designing innovative kits to test the comprehension and analysis of the experiment done by the students, v) audio visual recording of the experiments being performed by students and its self-appraisal

Formative assessment for computational physics work may include all of the components applicable in laboratory work assessment. It is essential that unseen problems are used in assessment of computational competence.

Since core courses, discipline specific courses, skill enhancement courses and general elective courses have qualitatively different kinds of objectives and learning outcomes, one model of assessment methods will not work for different kinds of courses.

7.1 ASSESSMENT METHODS FOR CORE COURSES

Core courses and associated laboratory curricula lead to the essential set of learning outcomes, which every physics graduate is expected to have. Their assessment methods require rigour, comprehensiveness and uniformity about what is minimally expected from students. Regular interactions mediated through university department among teachers teaching these courses in different colleges may prove to be helpful in this regard. Since depth of understanding of core topics is a highly desirable outcome, assessment for these courses should put greater emphasis on unseen problems, including extensions of textbook derivations done in class.

7.2 ASSESSMENT METHODS FOR DISCIPLINE SPECIFIC ELECTIVES

Discipline specific courses build upon general principles learnt in core courses, and also prepare students for further studies in specific domains of physics. Given the time constraint of only one semester, specific domain exposure is mostly introductory in character. Assessment for these courses should have significant component of open ended methods like seminars and project work. Students have greater chance of proving their individual initiative and ability for self-learning in these methods. These methods also have greater flexibility to reward students for out of curriculum learning.

7.3 ASSESSMENT METHODS FOR SKILL ENHANCEMENT COURSES

Learning in skill enhancement courses is largely experience based. Student performance in these courses is best assessed under continuous evaluation. Students could be assigned a specific task for a class or group of classes, and they could be assessed for their success in meeting the task.

7.4 ASSESSMENT METHODS FOR GENERIC ELECTIVES

General Elective courses are taken by students specializing in disciplines other than physics. The assessment methods for these courses should be oriented towards kindling student interest in the subject. Testing their ability to apply physics concepts in various practical situations through simple problems, and student specific writing and presentation assignments are most suited for assessing students' learning outcomes for these courses. Giving students greater choice of questions to be answered in semester end examinations, and asking a larger fraction of open-ended qualitative questions is recommended for these courses.

8. STRUCTURE OF COURSES IN B.Sc. (HONS.) PHYSICS

8.1 Credit Distribution for B.Sc. (Hons.) Physics

The B.Sc.(Hons.) Physics programme consists of 148 credits based on the Choice Based Credit System (CBCS) approved by the UGC. In a course 1 hour per week of theory or tutorial corresponds to one credit. 2 hours per week of practicals or hands-on work also correspond to one credit. The 148 credits include 84 credits of Core Courses (CC) and 8 credits of Ability Enhancement Compulsory Courses (AECC) which are mandatory. Choice is provided through 24 credits of Discipline Specific Electives (DSE), 8 credits of Skill Enhancement Courses (SEC) and 24 credits of Generic Elective Courses (GEC), the latter to be chosen from disciplines other than Physics.

Table 8.1 Table showing distribution of credits.

Semester	Core Courses (CC) each with 06 credit All 14 courses are compulsory	Generic Elective (GE). To be selected from GE listings of other disciplines	Skill Enhancement Course (SEC) Select any 2 Out of 11 courses	Discipline Specific Elective (DSE) Select four out of 20 courses	Ability Enhancement Compulsory Courses (AECC) Select any 2 out of 3 courses	Total Credit
Sem I	CC-I CC-II	GEC-1		-	AECC-1	22
Sem II	CC-III CC-IV	GEC-2		-	AECC-2	22
Sem III	CC-V CC-VI CC-VII	GEC-3	SEC-1	-	-	28
Sem IV	CC-VIII CC-IX CC-X	GEC-4	SEC-2	-	-	28
Sem V	CC-XI CC-XII	-		DSE-1 DSE-2	-	24
Sem VI	CC-XIII CC-XIV	-		DSE-3 DSE-4	-	24
Total Credit	**84**	**24**	**8**	**24**	**8**	**148**

Table 8.2 DETAILS OF COURSES UNDER B.Sc. (Hons.) PHYSICS

Course ***Credits**

Theory + Practical/Tutorials

==

I. Core Course

(14 Papers) $14 \times (4 + 2)^{\#} = 84$

Core Course (CC) + Practical*

II. Elective Course

(8 Papers)

A.1. **Discipline Specific Elective*** $4 \times (4 + 2)^{\#} = 24$ or $4 \times (5 + 1)^{\#\#} = 24$

(DSE + Practical/Tutorial)

(4 Papers)

B.1. Generic Elective/

Interdisciplinary***** $4 \times (4 + 2)^{\#} = 24$ or $4 \times (5 + 1)^{\#\#} = 24$

(GEC + Practical/Tutorial)

(4 Papers)

Optional Dissertation or project work in place of one Discipline Specific Elective **paper (6 credits) in 6th Semester**

III. Ability Enhancement Courses

1. **Ability Enhancement Compulsory**

(2 Papers of 4 credit each) 2 X 4 = 8

Environmental Science

English/MIL Communication

2. **Ability Enhancement Elective** (Skill Based) *****

(2 Papers of 4 credit each) $2 \text{ X } (2 + 2)^{\#} = 8$

Total Credits 148

College should evolve a system/policy about ECA/Interest/Hobby/ Sports/NCC/ NSS/related courses on its own.

#**Theory with practical/ Hands-on Exercise**

##**Theory with tutorials**

*** Wherever there is a practical there will be no tutorial and vice-versa. The maximum size of group for practical papers is recommended to be 12 to 15 students and for tutorials 8 to 10 students per group**.

8.2 SEMESTER-WISE DISTRIBUTION OF COURSES

CORE COURSES (CC)

Table 8.3 All the courses have 6 credits with 4 credits of theory (4 hours per week) and 2 credits of practicals (4 hours per week).

Core Course type	Unique Paper Code	Semester	Core Papers
CC-I	32221101	I	Mathematical Physics – I (Theory + Lab)
CC-II	32221102	I	Mechanics (Theory + Lab)
CC-III	32221201	II	Electricity and Magnetism (Theory + Lab)
CC-IV	32221202	II	Waves and Optics (Theory + Lab)
CC-V	32221301	III	Mathematical Physics – II (Theory + Lab)
CC-VI	32221302	III	Thermal Physics (Theory + Lab)
CC-VII	32221303	III	Digital Systems and Applications (Theory + Lab)
CC-VIII	32221401	IV	Mathematical Physics – III (Theory + Lab)
CC-IX	32221402	IV	Elements of Modern Physics (Theory + Lab)
CC-X	32221403	IV	Analog Systems and Applications (Theory + Lab)
CC-XI	32221501	V	Quantum Mechanics and Applications (Theory + Lab)
CC-XII	32221502	V	Solid State Physics (Theory + Lab)
CC-XIII	32221601	VI	Electromagnetic Theory (Theory + Lab)
CC-XIV	32221602	VI	Statistical Mechanics (Theory + Lab)

DISCIPLINE SPECIFIC ELECTIVES (DSE)

Table 8.4 All the courses have 6 credits with 4 credits of theory and 2 credits of practical or 5 credits of theory and 1 credit of Tutorials.

Discipline Specific (Physics) Elective papers (Credit: 06 each): Select any 02 papers (DSE-1 and DSE-2)* in V semester and Select any 02 papers (DSE-3 and DSE-4) in VI semester from the following options. **(numbers in brackets indicate number of hours per week dedicated)**

No.	Unique Paper Code	DSE Papers
Odd Semester – V Semester only (DSE-1 and DSE-2)		
1	32227501	Experimental Techniques (4) + Lab (4)
2	32227502	Advanced Mathematical Physics (4) + Lab (4)*
3	32227504	Nuclear and Particle Physics (5) + Tutorials (1)
4	32227505	Physics of Devices and Communication (4) + Lab (4)
5	32227506	Astronomy and Astrophysics (5) + Tutorials (1)
6	32227507	Atmospheric Physics (4) + Lab (4)
7	32227508	Biological Physics (5) + Tutorials (1)
8	32227518	Embedded Systems– Introduction of Microcontroller (4) + Lab(4)
9	xxx3	Linear Algebra and Tensor Analysis (5) + Tutorial (1)*
Even Semester – VI semester only (DSE-3 and DSE-4)		
10	32227612	Nano Materials and Applications (4) + Lab (4)
11	32227613	Communication System (4) + Lab (4)
12	32227615	Medical Physics (4) + Lab (4)
13	32227616	Applied Dynamics (4) + Lab (4)
14	32227621	Digital Signal processing (4) + Lab (4)
15	32227624	Physics of the Earth (5) + Tutorials (1)
16	32227625	Advanced Mathematical Physics II (5) + Tutorial (1)
17	32227626	Classical Dynamics (5) + Tutorial (1)
18	32227627	Dissertation (8)
19	32227628	Verilog and FPGA based system design (4) + Lab (4)
20	xxx4	Advanced Quantum Mechanics (5) + Tutorials (1)

*Papers listed at S. No. 02 (Advanced Mathematical Physics) and 09 (Linear Algebra and Tensor Analysis) are not allowed to be taken together as DSE-1 and DSE-2 in Semester-V.

SKILL ENHANCEMENT COURSES (SEC)

Table 8.5 All courses have 4 credits with 2 credits of theory and 2 credits of Practical /Hands-On/Projects and Field Work to be decided by the College. *Teachers may give a long duration project based on a SEC paper in the Practical Lab.*

No.	Unique Paper Code	Semester	SEC Papers
1	32223901	III/IV	Physics Workshop Skills
2	32223902	III/IV	Computational Physics Skills
3	32223903	III/IV	Electrical Circuit and Network Skills
4	32223904	III/IV	Basic Instrumentation Skills
5	32223905	III/IV	Renewable Energy and Energy Harvesting
6	32223906	III/IV	Engineering design and prototyping/Technical Drawing
7	32223907	III/IV	Radiation Safety
8	32223908	III/IV	Applied Optics
9	32223909	III/IV	Weather Forecasting
10	XXX1	III/IV	Introduction to Physical Computing
11	XXX2	III/IV	Numerical Analysis

ABILITY ENHANCEMENT COMPULSORY COURSES (AECC)

Table 8.6 All the courses have 4 credits. The detailed content of these courses is NOT mentioned in this document.

AECC	B.Sc. (Hons.) Physics
1	English
2	MIL Communications
3	Environment Science

GENERAL ELECTIVE COURSES (GE)

Table 8.7 All the courses have 6 credits including Theory/Practicals/ Projects. These courses are meant for students studying B.Sc. (Hons.) of other disciplines.

No.	Unique Paper Code	Semester	GE Papers
1	32225101	I	Electricity and Magnetism + Lab
2	32225102	I	Mathematical Physics + Lab
3	32225103	I	Digital, Analog and Instrumentation + Lab
4	32225104	I	Applied Dynamics + Lab
5	32225105	I	Medical Physics + Lab
6	32225201	II	Mechanics + Lab
7	32225202	II	Elements of Modern Physics + Lab
8	32225203	II	Solid State Physics + Lab
9	32225204	II	Embedded Systems – Introduction of Microcontroller + Lab
10	32225205	II	Biological Physics + Tutorial
11	32225310	III	Waves and Optics + Lab
12	32225311	III	Quantum Mechanics + Lab
13	32225312	III	Communication System + Lab
14	32225313	III	Verilog and FPGA based system design + Lab
15	32225314	III	Nano Materials and Applications + Lab
16	32225415	IV	Thermal Physics and Statistical Mechanics + Lab
17	32225416	IV	Digital Signal processing + Lab
18	32225417	IV	Nuclear and Particle Physics + Tutorial
19	32225418	IV	Astronomy and Astrophysics + Tutorial
20	32225419	IV	Atmospheric Physics + Lab
21	32225420	IV	Physics of the Earth + Tutorial

Table 8.8 Semester-wise breakup of types of courses with their credits.
Core Courses are listed in Table 8.3
GE courses are to be chosen from the course listings of other Departments.
SEC courses are to be chosen from Table 8.5
DSE courses are to be chosen from Table 8.4

S.No.	Course opted	Course name	Credits
I	Ability Enhancement Compulsory Course-I	English/ MIL communications/ Environmental Science	4
	Core course I	Mathematical Physics-I	4
	Core Course-I Practical*	Mathematical Physics-I Lab	2
	Core course-II	Mechanics	4
	Core Course-II Practical*	Mechanics Lab	2
	Generic Elective -1	GE-1	4/5
	Generic Elective – 1 Practical/Tutorial*	GE-1 Lab/Tutorial	2/1
II	Ability Enhancement Compulsory Course-II	English/MIL communications/ Environmental Science	4
	Core course-III	Electricity and Magnetism	4
	Core Course-III Practical*	Electricity and Magnetism Lab	2
	Core course-IV	Waves and Optics	4
	Core Course-IV Practical *	Waves and Optics Lab	2
	Generic Elective -2	GE-2	4/5
	Generic Elective -2 Practical/Tutorial*	GE-2 Lab/Tutorial	2/1
III	Core Course-V	Mathematical Physics-II	4
	Core Course-V Practical*	Mathematical Physics-II Lab	2
	Core course-VI	Thermal Physics	4
	Core Course-VI Practical*	Thermal Physics Lab	2
	Core course-VII	Digital Systems and Applications	4
	Core Course-VII Practical*	Digital Systems & Applications Lab	2
	Skill Enhancement Course -1	SEC-1	2
	Skill Enhancement Course -1 Practical*	SEC-1 Lab/Hands-on/field work/project	2
	Generic Elective -3	GE-3	4/5
	Generic Elective -3 Practical/Tutorial*	GE-3 Lab/Tutorial	2/1
IV	Core course-VIII	Mathematical Physics III	4
	Course-VIII Practical/Tutorial*	Mathematical Physics-III Lab	2
	Core course-IX	Elements of Modern Physics	4
	Course-IX Practical/Tutorial*	Elements of Modern Physics Lab	2
	Core Course-X	Analog Systems and Applications	4
	Course- X Practical/Tutorial*	Analog Systems & Applications Lab	2
	Skill Enhancement Course -2	SEC -2	2
	Skill Enhancement Course -2 Practical*	SEC -2 Lab/Hands-on/field work/project	2
	Generic Elective -4	GE – 4	4/5
	Generic Elective-4 Practical/Tutorial*	GE – 4 Lab/Tutorial	2/1
V	Core course-XI	Quantum Mechanics & Applications	4

	Core Course-XI Practical*	Quantum Mechanics Lab	2
	Core course-XII	Solid State Physics	4
	Core Course-XII Practical*	Solid State Physics Lab	2
	Discipline Specific Elective -1	DSE-1	4/5
	Discipline Specific Elective -1 Practical/Tutorial*	DSE-1 Lab/Tutorial	2/1
	Discipline Specific Elective -2	DSE-2	4/5
	Discipline Specific Elective- 2 Practical/Tutorial*	DSE-2 Lab/Tutorial	2/1
VI	Core course-XIII	Electro-magnetic Theory	4
	Core Course-XIII Practical*	Electro-magnetic Theory Lab	2
	Core course-XIV	Statistical Mechanics	4
	Core Course-XIV Practical*	Statistical Mechanics Lab	2
	Discipline Specific Elective -3	DSE-3	4/5
	Discipline Specific Elective -3 Practical/Tutorial*	DSE-3 Lab/Tutorial	2/1
	Discipline Specific Elective-4	DSE-4	4/5
	Discipline Specific Elective -4 Practical/Tutorial*	DSE-4 Lab/Tutorial	2/1
		TOTAL	**148**

*** Wherever there is a practical there will be no tutorial and vice-versa.**
The maximum size of group for practical papers is recommended to be 12 to 15 students and for tutorials 8 to 10 students per group.

9. DETAILED COURSES FOR PROGRAMME IN B.SC. (HONS.) PHYSICS, INCLUDING COURSE OBJECTIVES, LEARNING OUTCOMES, AND READINGS.

9.1. Core Courses

CC-I: Mathematical Physics-I (32221101)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists.
- To expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems.
- To help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers.

Course Learning Outcomes

- Revise the knowledge of calculus, vectors, vector calculus, probability and probability distributions. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering.
- Draw and interpret graphs of various functions.
- Solve first order differential equations and apply it to physics problems solve linear second order homogeneous and non-homogeneous differential equations with constant coefficients.
- Calculate partial derivatives of function of several variables Understand the concept of gradient of scalar field and divergence and curl of vector fields.
- Perform line, surface and volume integration and apply Green's, Stokes' and Gauss's Theorems to compute these integrals.
- Apply curvilinear coordinates to problems with spherical and cylindrical symmetries.
- Understand elementary probability theory and the properties of discrete and continuous distribution functions.
- In the laboratory course, learn the fundamentals of the C and C++ programming languages. Also, understanding Monte Carlo techniques, fitting a given data to linear function using method of least squares, approximation of a function by Maclaurin and Taylor’s series, finding roots of a given equation and their applications in solving simple physical problems.

Unit 1

Calculus

Functions: Recapitulate the concept of functions. Plot and interpret graphs of functions using the concepts of calculus.

(2 Lectures)

First Order Differential Equations: First order differential Equations: Variable separable, homogeneous, non-homogeneous, exact and inexact differential equations and Integrating Factors. Application to physics problems.

(5 Lectures)

Second Order Differential Equations: Homogeneous Equations with constant coefficients. Wronskian and general solution. Particular Integral with operator method, method of undetermined coefficients and method of variation of parameters. Cauchy-Euler differential equation and simultaneous differential equations of First and Second order.

(13 Lectures)

Unit 2

Vector Analysis

Vector Algebra: Scalars and vectors, laws of vector algebra, scalar and vector product, triple scalar product, interpretation in terms of area and volume, triple cross product, product of four vectors. Scalar and vector fields.

(5 Lectures)

Vector Differentiation: Ordinary derivative of a vector, the vector differential operator ∇. Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Laplacian operators. Vector identities.

(8 Lectures)

Vector Integration: Ordinary Integrals of Vectors. Double and Triple integrals, change of order of integration, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Scalar and Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their verification (no rigorous proofs).

(14 Lectures)

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

(6 Lectures)

Unit 3

Probability and statistics: Independent and dependent event, Conditional Probability. Bayes' Theorem, Independent random variables, Probability distribution functions, special distributions: Binomial, Poisson and Normal. Sample mean and variance and their confidence intervals for Normal distribution.

(7 Lectures)

Practical : 60 Hours

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- Highlights the use of computational methods to solve physics problems.
- The course will consist of lectures (both theory and practical) in the Lab. The recommended group size is not more than 15 students.
- Evaluation to be done not on the programming but on the basis of formulating the problem.
- Aim at teaching students to construct the computational problem to be solved.
- Students can use any one operating system: Linux or Microsoft Windows.
- At least 12 programs must be attempted from the following covering the entire syllabus.
- The list of programs here is only suggestive. Students should be encouraged to do more practice.

Topics	Descriptions with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices,
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, single and double precision arithmetic, underflow and overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Algorithms and Flow charts	Purpose, symbols and description,
Introduction to C++	Introduction to Programming: Algorithms: Sequence, Selection and Repetition, Structured programming, basic idea of Compilers. Data Types, Enumerated Data, Conversion & casting, constants and variables, Mathematical, Relational, Logical and Bit wise Operators. Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables. Programs: • To calculate area of a rectangle • To check size of variables in bytes (Use of sizeof( ) Operator) • converting plane polar to Cartesian coordinates and vice versa

C++ Control Statements	if-statement, if-else statement, Nested if Structure, Else-if statement, Ternary operator, Goto statement, switch statement, Unconditional and Conditional looping, While loop, Do-while loop, For loop, nested loops, break and continue statements Programs: • To find roots of a quadratic equation • To find largest of three numbers • To check whether a number is prime or not • To list Prime numbers up to 1000
Random Number generator	Generating pseudo random numbers To find value of pi using Monte Carlo simulations. To integrate using Monte Carlo Method
Arrays and Functions	Sum and average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order using Bubble sort and Sequential sort, Binary search, 2-dimensional arrays, matrix operations (sum, product, transpose etc)
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha$; $I=I_0 [(\sin \alpha)/ \alpha]^2$ in optics, square root of a number.
Data Analysis and Least Square Fitting (Linear case)	Uncertainty, error and precision, mean, standard deviation and error in the mean. Combining uncertainties, Least squares method for fitting data: linear ($y = ax+b$), power law($y = ax^b$) and exponential ($y = ae^{bx}$). To find parameters a, b and errors in them using method of least squares. Ohms law- calculate R, Hooke's law - Calculate spring constant.
Numerical differentiation (Forward and Backward and central difference formulae – Using basic definition)	Given Position with equidistant time data calculate velocity and acceleration

References for Theory:

1. Advanced Engineering Mathematics, D. G. Zill and W. S. Wright, 5 Ed., 2012, Jones and Bartlett Learning.
2. Mathematical Physics, Goswami, 1st edition, Cengage Learning.
3. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press.
4. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India .
5. Mathematical Physics (1995), A.K. Ghatak, IC Goyal and S.J. Chua, Macmillan India, New Delhi.
6. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press.

7. An introduction to ordinary differential equations, E. A. Coddington, 2009, PHI learning.
8. Differential Equations, George F. Simmons, 2007, McGraw Hill.
9. Vector Analysis: Schaum Outline Series, M. Spiegel, McGraw Hill Education (2017).
10. Introduction to Vector Analysis, H.F. Davis and A. D. Snider, Wm. C. Brown Publishers; 6th edition (1991).
11. Statistical data Analysis for The Physical Sciences by Adrian Bevan, Cambridge University Press (2013).
12. Statistics – A Guide to the Use of Statistical Methods n the Physical Sciences, R.J. Barlow, Wiley (1993).

References for Practical:

1. ‘Schaum's Outline of Programming with C++’, J.Hubbard, 2000, McGraw-Hill Education.
2. C++ How to Program’, Paul J. Deitel and Harvey Deitel, Pearson (2016).
3. Introduction to Numerical Analysis, S.S. Sastry, 5^{th} Edn., 2012, PHI Learning Pvt. Ltd.
4. An introduction to Numerical methods in C++, Brian H. Flowers, 2009, Oxford University Press.
5. A first course in Numerical Methods, U.M. Ascher & C. Greif, PHI Learning (2012).
6. Computational Physics, Darren Walker, 1^{st} Edn., Scientific International Pvt. Ltd (2015).
7. Applied numerical analysis, Cutis F. Gerald and P.O. Wheatley, Pearson Education, India (2007).

Additional References for Practical

1. ‘The C++ Programming Language, Bjarne Stroustrup, Addison-Wesley Professional (2013)
2. Numerical Recipes in C++: The Art of Scientific Computing, W.H. Press et.al., 2^{nd}Edn., Cambridge University Press (2013).
3. An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).
4. Elementary Numerical Analysis, K.E. Atkinson, 3^{rd} Edn., 2007, Wiley India Edition.

CC-II: Mechanics (32221102)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This course begins with the review of Newton's Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity. Students will also appreciate the Collisions in CM Frame, Gravitation, Rotational Motion and Oscillations. The emphasis of this course is to enhance the understanding of the basics of mechanics. By the end this course, students should be able to solve the seen or unseen problems/numerical in mechanics.

Course Learning Outcomes

Upon completion of this course, students are expected to understand the following concepts which would help them to appreciate the application of the fundamental concepts to the analysis of simple, practical situations related to the real world:

- Understand laws of motion and their application to various dynamical situations.
- Learn the concept of Inertial reference frames and Galilean transformations. Also, the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
- Understand the analogy between translational and rotational dynamics, and application of both motions simultaneously in analyzing rolling with slipping.
- Understand variable mass system and dynamics of a system of particles.
- Able to write the expression for the moment of inertia about the given axis of symmetry for different uniform mass distributions.
- Understand the phenomena of collisions and idea about center of mass and laboratory frames and their correlation.
- Understand conservative and non-conservative forces and also Potential Energy diagrams
- Understand angular momentum of a system of particle.
- Apply Kepler's law to describe the motion of planets and satellite in circular orbit, through the study of law of Gravitation.
- Understand concept of Geosynchronous orbits
- Explain the phenomenon of simple harmonic motion. Also, quality factor of forced oscillations
- Understand the concept of Centrifugal force and Coriolis forces
- Understand special theory of relativity - special relativistic effects and their effects on the mass and energy of a moving object.
- In the laboratory course, the student shall perform experiments related to mechanics

(compound pendulum), rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity), fluid dynamics, estimation of random errors in the observations etc.

Unit 1

Fundamentals of Dynamics: Reference frames, Inertial frames, Galilean transformations, Galilean invariance, Review of Newton's Laws of Motion. Momentum of variable mass system: motion of rocket. Dynamics of a system of particles. Principle of conservation of momentum. Impulse. Determination of Centre of Mass of discrete and continuous objects having cylindrical and spherical symmetry (1-D, 2-D & 3-D).

(5 Lectures)

Unit 2

Work and Energy: Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable, unstable and neutral equilibrium. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

(5 Lectures)

Collisions: Elastic (1-D and 2-D) and inelastic collisions. Centre of Mass and Laboratory frames.

(4 Lectures)

Unit 3

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of inertia, theorem of parallel and perpendicular axes. Determination of moment of inertia of discrete and continuous objects [1-D, 2-D & 3-D (rectangular, cylindrical and spherical)]. Kinetic energy of rotation. Motion involving both translation and rotation.

(10 Lectures)

Unit 4

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere.

(2 Lectures)

Motion of a particle under a central force field: Two-body problem, its reduction to one-body problem and its solution. Reduction of angular momentum, kinetic energy and total energy. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit, Geosynchronous orbits.

(7 Lectures)

Unit 5

Oscillations: Idea of SHM. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Compound pendulum. Damped oscillation. Forced oscillations: Transient and steady states, sharpness of resonance and Quality Factor.

(5 Lectures)

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Centrifugal force. Coriolis force and its applications**.**

(7 Lectures)

Unit 6

Special Theory of Relativity: Outcomes of Michelson-Morley Experiment. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity, Length contraction, Time dilation. Relativistic transformation of velocity, acceleration, frequency and wave number. Mass of relativistic particle. Mass-less Particles. Mass-energy Equivalence. Relativistic Doppler effect (transverse and longitudinal). Relativistic Kinematics (decay problems, inelastic collisions and Compton effect). Transformation of Energy and Momentum.

(15 Lectures)

Practical : 60 Hours

Demonstration cum laboratory sessions on the construction and use of Vernier callipers, screw gauge and travelling microscope, and necessary precautions during their use.

Sessions and exercises on the least count errors, their propagation and recording in final result up to correct significant digits, linearization of data and the use of slope and intercept to determine unknown quantities.

Session on the writing of scientific laboratory reports, which may include theoretical and practical significance of the experiment performed, apparatus description, relevant theory, necessary precautions to be taken during the experiment, proper recording of observations, data analysis, estimation of the error and explanation of its sources, correct recording of the result of the experiment, and proper referencing of the material taken from other sources (books, websites, research papers, etc.)

At least 06 experiments from the following

1. Measurements of length (or diameter) using Vernier Calliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the motion of the spring and calculate (a) Spring constant and, (b) g.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique.
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).

8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
10. To determine the elastic Constants of a wire by Searle's method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater's Pendulum.

References for Theory:

1. An Introduction to Mechanics, Daniel Kleppner & Robert Kolenkow, 2007, Tata McGrawHill
2. Mechanics, DS Mathur, PS Hemne, 2012, S. Chand
3. University Physics, FW Sears, MW Zemansky & HD Young 13/e, 1986, Addison Wesley
4. Mechanics Berkeley Physics course, v.1: Charles Kittel, et.al. 2007,
5. Tata McGraw Hill Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
6. Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press
7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole

References for Practical:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.
4. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.
5. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011,Kitab Mahal
6. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
7. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
8. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.

CC-III: Electricity and Magnetism (32221201)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

Electricity and Magnetism is one of the core courses in Physics curriculum. The course covers static and dynamic electric and magnetic field, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. By the end of the course student should be able to appreciate Maxwell's equations and analyze electrical circuits using network theorems.

Course Learning Outcomes

- Demonstrate the application of Coulomb's law for the electric field, and also apply it to systems of point charges as well as line, surface, and volume distributions of charges.
- Demonstrate an understanding of the relation between electric field and potential, exploit the potential to solve a variety of problems, and relate it to the potential energy of a charge distribution.
- Exploit alternative coordinate systems (cylindrical and spherical coordinates) to solve problems.
- Apply Gauss's law of electrostatics to solve a variety of problems.
- Demonstrate an understanding of electric dipoles and the role of molecular dipoles in the electrostatic response of dielectrics.
- Demonstrate an understanding of the behavior of electric conductors.
- Demonstrate a working understanding of capacitors.
- Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot- Savart and Ampere laws)
- Understand the concepts of induction and self-induction, to solve problems using Faraday's and Lenz's laws
- Apply Kirchhoff's rules to analyze AC circuits consisting of parallel and/or series combinations of voltage sources and resistors and to describe the graphical relationship of resistance, capacitor and inductor.
- Deal with electromagnetic oscillations, AC currents and oscillation circuits and analyze and solve LCR circuits
- Understand the basics of electrical circuits and analyze circuits using Network Theorems such as Superposition, Thevenin, Norton, Reciprocity, Maximum Power Transfer, etc.
- In the laboratory course the student will get an opportunity to verify network theorems and study different circuits such as RC circuit, LCR circuit.
- Different methods to measure low and high resistance, capacitance, self-inductance, mutual inductance and also strength of a magnetic field and its variation (dB/dX)

Unit 1

Electric Field and Electric Potential: Electric field: Electric field lines. Electric flux. Gauss Law with applications to charge distributions with spherical, cylindrical and planar symmetry.

(6 Lectures)

Conservative nature of Electrostatic Field:. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.

(6 Lectures)

Electrostatic energy of system of charge:. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

(10 Lectures)

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics.

(8 Lectures)

Unit 2

Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole).Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of **B**: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.

(9 Lectures)

Magnetic Properties of Matter: Magnetization vector (**M**). Magnetic Intensity (**H**). Magnetic Susceptibility and permeability. Relation between **B**, **H**, **M**. Ferromagnetism. B-H curve and hysteresis.

(4 Lectures)

Electromagnetic Induction: Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

(6 Lectures)

Unit 3

Electrical Circuits: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.

(5 Lectures)

Network theorems: Ideal constant-voltage and constant-current Sources. Review of Kirchhoff's Current Law& Kirchhoff's Voltage Law. Mesh &Node Analysis. Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity Theorem, Maximum Power Transfer theorem. Applications to dc circuits.

(6 Lectures)

Practical : 60 Hours

Dedicated demonstration cum laboratory sessions on the construction, functioning and uses of different electrical bridge circuits, and electrical devices like the ballistic galvanometer.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
Sessions on least square fitting and computer programme to find slope and intercept of straight-line graphs of experimental data. Application to the specific experiments done in the lab.

At least 6 experiments from the following:

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To compare capacitances using De'Sauty's bridge.
5. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self inductance of a coil by Anderson's bridge.
9. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
11. Measurement of charge sensitivity, current sensitivity and CDR of Ballistic Galvanometer
12. Determine a high resistance by leakage method using Ballistic Galvanometer.
13. To determine self-inductance of a coil by Rayleigh's method.
14. To determine the mutual inductance of two coils by Absolute method.

References for Theory:

1. Fundamentals of Electricity and Magnetism, Arthur F. Kip, 2nd Edn.1981, McGraw-Hill.
2. Electricity, Magnetism & Electromagnetic Theory, S.Mahajanand Choudhury, 2012, Tata McGraw
3. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
4. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.

5. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
6. Electricity and Magnetism, J.H.Fewkes& J.Yarwood. Vol.I, 1991, Oxford Univ. Press.
7. Problems and Solutions in Electromagnetics (2015), Ajoy Ghatak, K Thyagarajan & Ravi Varshney.
8. Network, Lines and Fields, John D. Ryder, 2nd Edn., 2015, Pearson.
9. Schaum's Outline of Electric Circuits, J. Edminister & M. Nahvi, 3rd Edn., 1995, McGraw Hill.

References for Practical:

1. Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011,Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. Engineering Practical Physics, S.Panigrahi and B.Mallick,2015, Cengage Learning.
5. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
6. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
7. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
8. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.

CC-IV: Waves and Optics (32221202)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This is one of the core course in Physics curriculum that begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves. The course also provides an in depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

Course Learning Outcomes

On successfully completing the requirements of this course, the students will have the skill and knowledge to:

- Understand Simple harmonic oscillation and superposition principle.
- Understand superposition of a range of collinear and mutually perpendicular simple harmonic motions and their applications.
- Understand the importance of classical wave equation in transverse and longitudinal waves and solving a range of physical systems on its basis.
- Understand different types of waves and their velocities: Plane, Spherical, Transverse, Longitudinal.
- Understand Concept of normal modes in transverse and longitudinal waves: their frequencies and configurations.
- Understand the concept of temporal and spatial coherence.
- Understand Interference as superposition of waves from coherent sources derived from same parent source.
- Demonstrate understanding of Interference experiments: Young's Double Slit, Fresnel's biprism, Llyod's Mirror, Newton's Rings, Michelson Interferometer and Fabry-Perot Interferometer
- Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from apertures
- Understand Fraunhoffer Diffraction from apertures: Rectangular, Slit, Double Slit, Grating, Circular apertures.
- Demonstrate fundamental understanding of Fresnel Diffraction: Half period zones, Zone Plate, Fresnel's Integrals, Cornu's Spiral and its applications.
- In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Rings experiment, Fresnel Biprism etc. Resolving power of optical equipment can be learnt first hand.
- The motion of coupled oscillators, study of Lissajous figures and behaviour of transverse, longitudinal waves can be learnt in this laboratory course.

Unit 1

Superposition of Collinear Harmonic oscillations: Simple harmonic motion (SHM). Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.

(6 Lectures)

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequencies and their uses.

(2 Lectures)

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave.

(4 Lectures)

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to

Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.

(8 Lectures)

Unit 2

Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

(4 Lectures)

Interference: Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

(10 Lectures)

Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.

(6 Lectures)

Unit 3

Diffraction:

Fraunhofer diffraction: Single slit. Rectangular and Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

(10 Lectures)

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Cornu`s spiral and its applications. Straight edge, a slit and a wire.

(10 Lectures)

Practical: 60 Hours

Dedicated demonstration cum laboratory session on the construction, and use of spectrometer and lasers, and necessary precautions during their use.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 06 experiments from the following:

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2–T law.
2. To investigate the motion of coupled oscillators.

3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel Biprism.
9. To determine wavelength of sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.

References for Theory:

1. Vibrations and Waves, A.P. French, 1stEdn., 2003, CRC press.
2. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
3. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
4. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
5. Optics, (2017), 6th Edition, Ajoy Ghatak, McGraw-Hill Education, New Delhi
6. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
7. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
8. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications
9. Optics, Eugene Hecht, 4thEdn., 2014, Pearson Education.

References for Practical:

1. Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011,Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal,1985, Vani Pub.
5. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
6. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
7. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
8. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.

CC-V: Mathematical Physics-II (32221301)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- The emphasis of course is to equip students with the mathematical tools required in solving problems interest to physicists.
- To expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems
- To help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers.
- This course will aim at introducing the concepts of Fourier series, special functions, solving linear partial differential equations by separation of variable method.

Course Learning Outcomes

On successfully completing this course, the students will be able to

- Represent a periodic function by a sum of harmonics using Fourier series and their applications in physical problems such as vibrating strings etc..
- Expand an odd or even function as half range sine and cosine Fourier series.
- Obtain power series solution of differential equation of second order with variable coefficient using Frobenius method.
- Understand properties and applications of special functions like Legendre polynomials, Bessel functions functions and their differential equations and their applications in various physical problems such as in quantum mechanics.
- Learn about gamma and beta functions and their applications.
- Solve linear partial differential equations of second order with separation of variable method.
- In the laboratory course, learn the basics of the Scilab software, their utility, advantages and disadvantages.
- Apply appropriate numerical method to solve selected physics problems both using computer program in Scilab and using the inbuilt functions from Scilab.
- Analyze the errors obtained in numerical solution to problems and compare different algorithms with respect to accuracy and efficiency.
- Understand the algorithms of Newton and Lagrange interpolation and use them to find intermediate value in a tabulated data
- Perform numerical differentiation and integration (trapezoidal and Simpson methods) of a given function in mathematical or tabulated form

- Solve initial value problems using Euler and Runge Kutta methods.
- Obtain approximate solution to a system of linear equations using Gauss Elimination and Gauss Seidel methods
- Generate and plot Legendre polynomials and Bessel functions and verify their recurrence relation

Unit 1

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Even and odd functions and their Fourier expansions (Fourier Cosine Series and Fourier Sine Series). Application. Summing of Infinite Series. Parseval's Identity and its application to summation of infinite series.

(17 Lectures)

Unit 2

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations: Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions ($J_o(x)$ and $J_1(x)$) and Orthogonality.

(24 Lectures)

Unit 3

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.

(4 Lectures)

Unit 4

Partial Differential Equations: Solutions to partial differential equations (2 or 3 independent variables) using separation of variables: Laplace's Equation in problems of rectangular geometry. Solution of wave equation for vibrational modes of a stretched string, rectangular and circular membranes. Solution of 1D heat flow equation. (Wave/Heat equation not to be derived).

(15 Lectures)

Practical : 60 Hours

The aim of this Lab is to use the computational methods to solve physical problems. The course will consist of lectures (both theory and practical) in the Computer Lab. The recommended group size for the lab is not more than 15 students. Evaluation done not on the basis of programming but on the basis of formulating the problem. Minimum 12 programs must be attempted taking at least one from each programming section. The instructor may chose to use Python in place of Scilab covering all features as mentioned.

Topics	Description with Applications
Introduction to Numerical computation software Scilab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Sub-array, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting, Branching Statements and program design, Relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements, nested loops, logical arrays and vectorization. User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program.
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation. Lagrange Interpolation.	Evaluation of trigonometric functions e.g. *sin(x), cos(x), tan(x)* etc – Given the values at n points in a tabulated form, evaluate the value at an intermediate point.
Numerical Integration: Newton Cotes Integration methods (Trapezoidal and Simpson rules) for definite integrals	Given acceleration with equidistant time data calculate position and velocity and plot them. Application to other mathematical and physical problems
Solution of Linear system of equations: Solve system of linear equations using Gauss elimination method and Gauss Seidal method. Inverse of a matrix (by Gauss elimination)	Application to Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses)

Generation of Special functions using user defined functions and compare with Scilab built in functions	Generating and plotting Legendre Polynomials Generating and plotting Bessel functions Verification of recurrence relation Use the data obtained above for Legendre polynomials or Bessel's function at N points and find its value at an intermediate point using Lagrange interpolation.
Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods	First order differential equation (Initial value problems) Radioactive decay Current in RC, LC circuits with DC source Newton's law of cooling Classical equations of motion
System of First order Differential Equations	Attempt following problems using RK 4 order method: • Solve the coupled differential equations $dx/dt=y+x-x^3/3$; $dy/dt= -x$ for four initial conditions : $x(0) = 0$, $y(0) = -1, -2, -3, -4$. Plot x vs y for each of the four initial conditions on the same screen for $0 \le t \le 15$

Second order differential equation (Euler and RK Methods)	Second Order Differential Equations: Harmonic oscillator (no friction) Damped Harmonic oscillator (Overdamped, Critically damped and Oscillatory behaviour) Forced Harmonic oscillator (Transient and Steady state solution) Apply above to LCR circuits also The differential equation describing the motion of a pendulum is $\frac{d^2\theta}{dt^2} = -\sin\theta$. The pendulum is released from rest at an angular displacement α, i.e. $\theta(0) = \alpha$ and $\theta'(0) = 0$. Solve the equation for α = 0.1, 0.5 and 1.0 and plot $\theta, \frac{d\theta}{dt}$ as a function of time in the range $0 \leqslant t \leqslant 8\pi$. Also plot the analytic solution valid for small $\theta(\sin\theta \approx \theta)$ Solve $$x^2\frac{d^2y}{dx^2} - 4x(1+x)\frac{dy}{dx} + 2(1+x)y = x^3$$ with the initial conditions at x = 1 as $y(1) = \frac{1}{2}e^2, \frac{dy}{dx}(x=1) = \frac{-3}{2}e^2 - 0.5,$ in the range $1 < x < 3$. Plot y and $\frac{dy}{dx}$ against x in the given range on the same graph.
Using Scicos/xcos	Generating sine wave, square wave, sawtooth wave Solution of harmonic oscillator Phase space plots

References for Theory:

1. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
2. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
3. Mathematical methods for Scientists & Engineers, D.A.Mc Quarrie, 2003, Viva Books
4. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
5. Mathematical Physics, A.K. Ghatak, I.C. Goyal and S.J. Chua, Laxmi Publications Private Limited (2017)
6. Mathematical Methods for Physicists, Arfken, Weber and Harris, Elsevier

References for Practical:

1. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896.
2. Documentation at the Scilab homepage: https://www.scilab.org/tutorials
3. Documentation at the Python home page, https://docs.python.org/3/
4. Computational Physics, Darren Walker, Scientific International Pvt. Ltd (2015).
5. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., PHI Learning Pvt. Ltd. (2012).
6. Applied numerical analysis, Cutis F. Gerald and P.O. Wheatley, Pearson Education, India (2007).
7. An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).
8. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

Additional References for Practical:

1. Numerical Recipes : The Art of Scientific Computing, 3rd edition, W.H. Press et.al.,Cambridge University Press.
2. Numerical Analysis, Timothy Sauer, Pearson (2013).

CC-VI: Thermal Physics (32221302)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This coursework deal with the relationship between the macroscopic properties of the physical system in equilibrium. The primary goal is to understand the fundamental laws of thermodynamics and it's applications to various thermo dynamical systems and processes. In addition, it will also give exposure to students about the Kinetic theory of gases , transport phenomenon involved in ideal gases, phase transitions and behavior of real gases.

Course Learning Outcomes

At the end of the course, students will be able to:

- Comprehend the basic concepts of thermodynamics, the first and the second law of thermodynamics.
- Understand the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations.
- Know about reversible and Irreversible processes.
- Learn about Maxwell's relations and use them for solving many problems in Thermodynamics
- Understand the concept and behavior of ideal and real gases.
- Learn the basic aspects of kinetic theory of gases, Maxwell-Boltzman distribution law, equitation of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
- In the laboratory course, the students are expected to do some basic experiments in thermal Physics, viz., determination of Mechanical Equivalent of Heat (J), coefficient of thermal conductivity of good and bad conductor, temperature coefficient of resistance, variation of thermo-emf of a thermocouple with temperature difference at its two junctions and calibration of a thermocouple.

Unit 1

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

(8 Lectures)

Unit 2

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot‟s Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot‟s Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

(10 lectures)

Unit 3

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of

Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

(7 lectures)

Unit 4

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb"s Free Energy. Their Definitions, Properties and Applications. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations.

Maxwell's Thermodynamic Relations: Derivation of Maxwell"s thermodynamic Relations and their applications, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Value of Cp-Cv, (3) Tds Equations, (4) Energy equations.

(14 lectures)

Unit 5

Kinetic Theory of Gases Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.

Molecular Collisions: Mean Free Path. Collision Probability. Estimation of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.

(11 lectures)

Unit 6

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. Andrew"s Experiments on CO2 Gas. Virial Equation. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. van der Waal"s Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves.p-V Diagrams. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and vander Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.

(10 lectures)

Practical: 60 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the thermal physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne"s constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle"s Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom"s Method.

4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton"s disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions using a null method. And also calibrate the Thermocouple in a specified temperature range.
7. To calibrate a thermocouple to measure temperature in a specified Range using Op-Amp difference amplifier and to determine Neutral Temperature.

References for Theory:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press.
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill.
4. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
5. Concepts in thermal Physics: Blundell & Blundell , Oxford Univ. press
6. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

References for Practical:

1. Advanced Practical Physics for students, B. L. Flint and H.T.Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011,Kitab Mahal.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes,D.P.Khandelwal,1985, Vani Pub.
5. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
6. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
7. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
8. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.
9. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

CC-VII: Digital Systems and Applications (32221303)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This is one of the core papers in physics curriculum which introduces the concept of Boolean algebra and the basic digital electronics.
- In this course, students will be able to understand the working principle of CRO, Data processing circuits, Arithmetic Circuits, sequential circuits like registers, counters etc. based on flip flops.
- In addition, students will get an overview of microprocessor architecture and programming.

Course Learning Outcomes

This course lays the foundation for understanding the digital logic circuits and their use in combinational and sequential logic circuit design. It also imparts information about the basic architecture, memory and input/output organization in a microprocessor system. The students also learn the working of CRO.

- Course learning begins with the basic understanding of active and passive components. It then builds
- Concept of Integrated Chips (IC): its classification and uses.
- Differentiating with the Analog and Digital circuits, the concepts of number systems like Binary,
- BCD, Octal and hexadecimal are developed to elaborate and focus on the digital systems.
- Explains the concepts of logic states and logic gates AND, OR, NOT, NAND, NOR, XOR and XNOR as fundamental, universal and derived gates with its utility.
- Covers the realisation of NOT, OR and AND gates using diodes and transistors.
- Students learn how to write logical Boolean statements using the truth table, its simplification using Boolean Algebra, De-Morgan's Theorem and Karnaugh Maps specially the Sum of Products method and realise the corresponding logic circuit.
- Understanding and usage of various important categories of circuits are imparted.
- Data Processing Circuits that are used in communication systems for data selection and transmission.
- Some combinational circuits that perform arithmetic functions like addition and subtraction.
- Sequential Circuits: Beginning with the basic memory elements Flips-Flops, it develops to more elaborate circuits like shift registers and 4-bits counters to provide a basic idea about memory including RAM, ROM and also about memory organization.
- Timer circuits using IC 555 to provide clock pulses to sequential circuits and develop multivibrators.
- Expose students to the Input/output devices, memory organisation, memory interfacing and maps in computer systems.

- Introduces to basic architecture of processing in an Intel 8085 microprocessor and to Assembly Language.
- Also impart understanding of working of CRO and its usage in measurements of voltage, current, frequency and phase measurement.
- In the laboratory he is expected to construct both combinational circuits and sequential circuits by employing NAND as building blocks and demonstrate Adders, Subtractors, Shift Registers, and multivibrators using 555 ICs. He is also expected to use µP 8085 to demonstrate the same simple programme using assembly language and execute the programme using a µP kit.

Unit 1

Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

(3 Lectures)

Digital Circuits: Difference between Analog and Digital Circuits, Examples of linear and digital ICs, Binary Numbers, Decimal to Binary and Binary to Decimal Conversion, BCD, Octal and Hexadecimal numbers, AND, OR and NOT Gates (realisation using Diodes and Transistor), NAND and NOR Gates as Universal Gates, XOR and XNOR Gates and application as Parity Checkers.

(6 Lectures)

Unit 2

Boolean algebra: De Morgan's Theorems, Boolean Laws, Simplification of Logic Circuit using Boolean Algebra, Fundamental Products, Idea of Minterms and Maxterms, Conversion of Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **(7 Lectures)**

Data processing circuits: Multiplexers, De-multiplexers, Decoders, Encoders.

(4 Lectures)

Unit 3

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement, Half and Full Adders, Half & Full Subtractors, 4-bit binary Adder/Subtractor.

(5 Lectures)

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

(6 Lectures)

Unit 4

Timers: IC 555 block diagram and applications: Astable multivibrator and Monostable multivibrator.

(3 Lectures)

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in- Parallel-out Shift Registers (only up to 4 bits).

(2 Lectures)

Counters(4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

(4 Lectures)

Unit 5

Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization and addressing. Memory Interfacing. Memory Map.

(6 Lectures)

Unit 6

Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing and Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI.

(10 Lectures)

Introduction to Assembly Language: 1 byte, 2 byte and 3 byte instructions.

(4 Lectures)

Practical: 60 Hours

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 06 experiments each from section A and Section B

Section-A: Digital Circuits Hardware design/Verilog Design

1. To design a combinational logic system for a specified Truth Table.
(a) To convert Boolean expression into logic circuit &design it using logic gate ICs
(b) To minimize a given logic circuit.
2. Half Adder, Full Adder and 4-bit binary Adder.
3. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
4. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
5. To build JK Master-slave flip-flop using Flip-Flop ICs
6. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
7. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
8. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO and to design an astable multivibrator of given specifications using 555 Timer.
9. To design a monostable multivibrator of given specifications using 555 Timer.

Section-B: Programs using 8085 Microprocessor:

1. Addition and subtraction of numbers using direct addressing mode
2. Addition and subtraction of numbers using indirect addressing mode

3. Multiplication by repeated addition.
4. Division by repeated subtraction.
5. Handling of 16-bit Numbers.
6. Use of CALL and RETURN Instruction.
7. Block data handling.
8. Parity Check
9. Other programs (e.g. using interrupts, etc.).

References

1. Digital Principles and Applications, A.P.Malvino, D.P.Leach and G. Saha, 8th Ed., 2018, Tata McGraw Hill Education
2. Fundamentals of Digital Circuits, Anand Kumar, 4th Edn, 2018, PHI Learning Pvt. Ltd. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill
3. Digital Electronics G K Kharate ,2010, Oxford University Press
4. Logic circuit design, Shimon P. Vingron, 2012, Springer
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
6. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.
7. Digital Computer Electronics, A.P. Malvino, J.A. Brown, 3rd Edition, 2018, Tata McGraw Hill Education.
8. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill
9. Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1994, Mc-Graw Hill.
10. Microprocessor 8085: Architecture, Programming and interfacing, A.Wadhwa,2010, PHI Learning

CC-VIII: Mathematical Physics III (32221401)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

The emphasis of the course is on applications in solving problems of interest to physicists. Students are t be examined on the basis of problems, seen and unseen. Demonstrate understanding of the basic concepts underlying complex analysis and complex integration. Develop an understanding of Fourier and Laplace Transform to solve real world problems

Course Learning Outcomes

After completing this course, student will be able to

- Determine continuity, differentiability and analyticity of a complex function and find the derivative of a function.
- Understand properties of elementary complex functions (polynomials, reciprocals, exponential, trigonometric, hyperbolic, etc) of single complex variable.
- Work with multi-valued functions (logarithmic, complex power, inverse trigonometric function) and determine branches of these functions
- Evaluate a contour integral using parametrization, fundamental theorem of calculus and Cauchy's integral formula.
- Find the Taylor series of a function and determine its radius of convergence;
- Determine the Laurent series expansion of a function in different regions and find the residues use the residue theory to evaluate a contour integral and real integral.
- Find the Fourier transform and the inverse Fourier transform of a function and understand their properties
- Understand the properties of Laplace transform and inverse Laplace transform and use it to solve boundary value problems.
- In the laboratory course, the students should apply their C++/Scilab/Python programming language to solve the following problems:

  i. Solve boundary value problems represented by ordinary differential equations.
  ii. Perform numerical integration using Gauss quadrature methods.
  iii. Approximate a periodic function by a few terms in the Fourier series and understand the behavior at the point of discontinuity.
  iv. Understand the limit in which a Gaussian function behaves like a Dirac Delta Function
  v. Solve partial differential equations numerically.
  vi. Find fast Fourier transform and Laplace transform of a given function numerically.
  vii. Plot Legendre polynomials and the Bessel functions of different orders and interpretations of the results.
  viii. Weighted of a given data to a graph.

Unit 1

Complex Analysis

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De-Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Equations. Examples of analytic functions. Singularities: poles, removable singularity, essential singularity, branch points, branch cut. Integration of a function of a complex variable. Cauchy-Goursat Theorem, Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application of Contour Integration in solving Definite Integrals.

(30 Lectures)

Unit 2

Integrals Transforms

Fourier Transforms: Fourier Integral theorem (Statement only). Fourier Transform (FT). Examples: FT of single pulse, trigonometric, exponential and Gaussian functions. FT of derivatives, Inverse FT, Convolution theorem. Properties of FT s (translation, change of scale, complex conjugation, etc.). Solution of one dimensional Wave Equation using FT. Fourier Sine Transform (FST) and Fourier Cosine Transform (FCT).

(12 Lectures)

Unit 3

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations, Coupled differential equations of 1st order. Solution of 1-D heat equation (semi-infinite bar) using LT.

(15 Lectures)

Unit 4

Dirac delta function: Definition and properties. Representation of Dirac delta function as a Fourier Integral. Laplace and Fourier Transform of Dirac delta function.

(3 Lectures)

Practical: 60 Hours

The aim of this Lab is to use the computational methods to solve physical problems. The course will consist of lectures (both theory and practical) in the Computer Lab. Evaluation done not only on the basis of programming but also on the basis of formulating the problem. At least ten programs must be attempted taking at least one from each programming section. The program list is only suggestive and students should be encouraged to do more problems.

C++/C/Scilab/Python based simulations experiments on Mathematical Physics problems like

1. Boundary Value Problems :
- Solution to Ordinary Differential equation (Boundary Value Problems using finite Difference and shooting methods) :
  $y''(x) + y(x) = 0$ with $y(0) = 1, y(\pi/2) = 1$ solve for $0 < x < \pi$.
- Solve for the steady state concentration profile y(x) in the reaction-diffusion problem given by $y''(x) - y(x) = 0$ with $y(0) = 1, y'(1) = 0$.
- Solution to Partial Differential equation :
- Finite Difference and Crank-Nicholson methods to solve Laplace equation, wave equation, and Heat Equation.

2. Gauss Quadrature Integration Method : Gauss Legendre, Gauss Lagaurre and Gauss Hermite. :
- Verification of Orthogonality of Legendre Polynomials.

$$\int_{-1}^{+1} P_n(\mu) P_m(\mu) d\mu = \frac{2}{(2n+1)} \delta_{n,m}$$

- Complex analysis: Integrate $\int_{-\infty}^{\infty} \frac{1}{(x^2+2)} dx$ numerically and check with contour integration.

3. Dirac Delta Function: representations of Dirac delta function as a limiting sequence of functions. Verify the properties of Dirac Delta function. e.g. Evaluate
$\frac{1}{\sqrt{2\pi\sigma^2}} \int exp\left(\frac{-(x-2)^2}{2\sigma^2}\right)(x+3)dx$, for □ = 1, 0.1, 0.01 and show that it tends to 5. Use Hermite Gauss quadrature method and also Simpson method with appropriate limits.
4. Fourier Series:
- Program to sum $\sum_{n=1}^{\infty} (0.2)^n$
- Evaluate the Fourier coefficients of a given periodic function (e.g. square wave, triangle wave, half wave and full wave rectifier)

5. Least square fitting of linear line with weightage to error in data points for a given data set using user defined function.
6. Integral transform:
- Fast Fourier Transform of e^{-x^2}
- Perform circuit analysis of a general LCR circuit using Laplace's transform.

References for Practical:

1. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer.
2. Documentation at the Scilab homepage: https://www.scilab.org/tutorials

3. Documentation at the Python home page, https://docs.python.org/3/
4. Computational Physics, Darren Walker, Scientific International Pvt. Ltd (2015).
5. Introduction to Numerical Analysis, S.S. Sastry, 5^{th} Edn., PHI Learning Pvt. Ltd. (2012).
6. An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).
7. Elementary Numerical Analysis, K.E. Atkinson, 3^{rd} Edn., 2007, Wiley India Edition.
8. Partial Differential Equations for Scientists and Engineers, Stanley J. Farlow Dover Publications.

Additional References for Practical:

1. Numerical Recipes : The Art of Scientific Computing, 3^{rd} edition, W.H. Press et.al.,Cambridge University Press.
2. Numerical Analysis, Timothy Sauer, Pearson (2013).
3. Fourier Transform and Its Applications, 2^{nd} Edition (McGraw-Hill electrical and electronic engineering series)
4. Ronald Newbold Bracewell , McGraw-Hill; 2^{nd} edition (1978).

CC-IX: Elements of Modern Physics (32221402)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This course introduces modern development in Physics that ushered in relativity and quantum physics which not only revolutionized mankind's understanding of time, space, atomic and sub-atomic structures that make up the matter around us, but also led to fascinating developments in technology that are being witnessed all around us. Beginning with technological marvels like electronics, spectroscopy, semiconductor based devices, IC chips, lasers, harnessing of nuclear energy, satellite communication, atomic clocks, GPS, space travel, scanning tunneling microscope, nano-materials, nano-technology, CCDs, etc. modern physics brought forth useful tools in our daily lives like laptop computers, mobile phones, laser pointers, LEDs, LCD screens, so on and so forth. Therefore, the objective of this course is to teach the physical and mathematical foundations necessary for learning various topics in modern physics. Starting from Planck’s law, this course introduces experimental observation of photo-ejection of electrons, idea of wave-particle duality as well as Bohr model of atoms and, then it develops the formulation of Schrodinger equation and the idea of probability interpretation associated with wavefunctions. It also introduces basic underlying concepts involved in laser physics as well as that in nuclear physics, so crucial for high energy physics, nuclear technology and astrophysics.

Course Learning Outcomes

After getting exposure to this course, the following topics would be learnt:
Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.

- Quantum measurements and the theory of wave packets and uncertainty principle.
- The central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and time independent cases, probability density and the normalization techniques, skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier.
- The properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.
- Decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrino, its properties and its role in theory of beta decay.
- Fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
- Various interactions of electromagnetic radiation with matter. Electron positron pair creation.
- The spontaneous and stimulated emission of radiation, optical pumping and population inversion. Three level and four level lasers. Ruby laser and He-Ne laser in details. Basic lasing.
- In the laboratory course, the students will get opportunity to measure Planck's constant by more than one method, verify photoelectric effect and determination of the work Function of a metal, determine e/m of electron.
- Ionization potential of atoms, wavelength of the emission lines in the spectrum of Hydrogen atom, absorption lines in the rotational spectrum of molecules.
- The wavelength of Laser sources by single and Double slit experiment and the wavelength and angular spread of He-Ne Laser using plane diffraction grating.

Unit 1

Planck’s quantum, Planck’s constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Double-slit experiment with electrons. Probability. Wave amplitude and wave functions.

(12 Lectures)

Unit 2

Position measurement : gamma ray microscope thought experiment; Wave-particle duality leading to Heisenberg uncertainty principle; Uncertainty relations involving canonical pair of variables: Derivation from Wave Packets; Impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle: origin of natural width of emission lines as well as estimation of the mass of the virtual particle that mediates a force from the observed range of the force

(7 Lectures)

Unit 3

Two-slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

(10 Lectures)

Unit 4

One dimensional infinitely rigid box : energy eigenvalues, eigenfunctions and their normalization; Quantum dot as an example; Quantum mechanical scattering and tunneling in one dimension : across a step potential & across a rectangular potential barrier.
Lasers: Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion.

(14 Lectures)

Unit 5

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, N-Z graph, Liquid Drop model: semi-empirical mass formula and binding energy.

(6 Lectures)

Unit 6

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. Fission and fusion: mass deficit, relativity and generation of energy; Fission : nature of fragments and emission of neutrons. Fusion and thermonuclear reactions driving stellar evolution (brief qualitative discussions).

(11 Lectures)

Practical: 60 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the modern physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 05 experiments from the following:

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine the ionization potential of mercury.
4. To determine value of Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser and measure its intensity variation using Photosensor & compare with incoherent source– Na.
8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.

References

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Cooper, 2002, Tata McGraw Hill
3. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, Cengage Learning 2010
4. Quantum Mechanics: Theory and Applications, (2019), (Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi
5. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.30
6. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
7. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
8. Introduction to Modern Physics by M Mani & G K Mehta, Affiliated East-West Press, 1990.
9. Modern Physics by R A Serway, C J Moses and C A Moyer, 3rd edition, Thomson Brooks Cole, 2012.
10. Modern Physics for Scientists and Engineers by S T Thornton and A Rex, 4th edition, Cengage Learning, 2013.
11. Modern Physics by G Aruldhas and P Rajagopal. PHI Learning Pvt. Ltd., 2016.

Books for Numericals:

1. Schaum's Outline of Modern Physics, McGraw-Hill, 1999.
2. Schaum's Outline of College Physics, by E. Hecht, 11th edition, McGraw Hill, 2009.
3. Modern Physics by K Sivaprasath and R Murugeshan, S Chand Publication, 2010.
4. Quantum Mechanics: 500 problems and solutions by G. Aruldhas. PHI Learning Pvt. Ltd., 2016.

Additional Resources:

1. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore,2003, McGraw Hill
2. Thirty years that shook physics: the story of quantum theory, George Gamow, Garden City, NY : Doubleday, 1966
3. Quantum Theory, David Bohm, Dover Publications, 1979

4. Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019
5. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.

Suggested/Classic Readings:

1. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
2. Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
3. Nuclear Physics: principles and applications by J Lilley, Wiley Publication, 2006.

CC-X: Analog Systems and Applications (32221403)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This is one of the core papers i n physics curriculum where students will get to learn about the physics of semiconductor p-n junction and devices such as rectifier diodes, Zener diode, photodiode etc. and bipolar junction transistors.
- Transistor biasing and stabilization circuits are explained. The concept of feedback is discussed in amplifiers a the oscillator circuits are also studied.
- By the end of the syllabus, students will also have an understanding of operational amplifiers and their applications.

Course Learning Outcomes

At the end of this course, students will be able to develop following learning outcomes:

- To have knowledge about characteristics of semiconductor materials in terms of band structure, movement of charge carriers and to explain properties of n and p type semiconductors.
- To know the basic concepts of PN junction diode, its fabrication, conduction mechanism and determine its barrier potential and width.
- To learn structure and operation of simple PN junction devices such as LED, photo diodes, Solar cells, Zener diodes etc.

- To apply the basics of diodes to describe working of rectifier circuits and quantitatively explain effect of capacitance filter, line and load regulation
- NPN and PNP transistors and basic configurations namely common base, common emitter and common collector, and also about current and voltage gain.
- To understand the structure and operation of Bipolar Junction transistors. Also be able to explain various current components and characteristics of different configurations.
- To describe the application of transistors for current and voltage applications, need for biasing and stabilization in transistor amplifiers.
- To analyze single stage CE and two stage RC coupled transistor amplifier using h-parameter model of the transistor.
- To ingest the effect of feedback in amplifiers and apply them to design different type of oscillators.
- To distinguish ideal and practical op-amps, comprehend need for op-amps and their electrical parameters.
- To understand various operating modes of Op-amps and its linear and non-linear application particularly application as D to A and A to D converter and acquire skill to design circuits for different Op-amp applications.
- In the laboratory course, the students will design combinational logic system for a given equation minimizing the logic circuit, Adder, Subtractor, Flip-Flops, 4-bit counter, Shift Register, Multivibrator using 555 Timer.
- Also programming using 8085 Microprocessor

Unit 1

Semiconductor Diodes: P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity.PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Derivation for Barrier Potential, Barrier Width and Current for abrupt Junction. Equation of continuity, Current Flow Mechanism in Forward and Reverse Biased Diode.

(9 Lectures)

Unit 2

Two-terminal Devices and their Applications: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, (2) Zener Diode and Voltage Regulation. Principle, structure and characteristics of (1) LED, (2) Photodiode and (3) Solar Cell, Qualitative idea of Schottky diode and Tunnel diode.

(7 Lectures)

Unit 3

Bipolar Junction transistors: n-p-n and p-n-p Transistors. I-V characteristics of CB and CE Configurations. Active, Cutoff and Saturation Regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow.

(6 Lectures)

Unit 4

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network.h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers.

(10 Lectures)

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response.

(4 Lectures)

Unit 5

Feedback in Amplifiers: Positive and Negative Feedback. Effect of negative feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

(4 Lectures)

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

(4 Lectures)

Unit 6

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

(4 Lectures)

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Comparator and Zero crossing detector (8) Wein bridge oscillator.

(9 Lectures)

Conversion: D/A Resistive networks (Weighted and R-2R Ladder). Accuracy and Resolution.

(3 Lectures)

Practical : 60 Hours

Session on the construction and use of specific analogue devices and experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 08 experiments from the following:

1. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
2. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study the various biasing configurations of BJT for normal class A operation.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of voltage gain of a two stage RC-coupled transistor amplifier.
7. To design a Wien bridge oscillator for given frequency using an op-amp.

8. To design a phase shift oscillator of given specifications using BJT.
9. To design a digital to analog converter (DAC) of given specifications.
10. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
11. (a) To design inverting amplifier using Op-amp(741,351) & study its frequency response
    (b) To design non-inverting amplifier using Op-amp (741,351) & study frequency response
12. (a) To add two dc voltages using Op-amp in inverting and non-inverting mode
    (b) To study the zero-crossing detector and comparator.
13. To design a precision Differential amplifier of given I/O specification using Op-amp.
14. To investigate the use of an op-amp as an Integrator.
15. To investigate the use of an op-amp as a Differentiator.
16. To design a circuit to simulate the solution of simultaneous equation and 1st/2ndorder differential equation.

References

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
2. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI
3. Learning Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill OP-Amps
4. Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
5. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
6. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
7. Microelectronic Devices & Circuits, David A.Bell, 5th Edn.,2015, Oxford University Press
8. Basic Electronics: Principles and Applications, C.Saha, A.Halder, D.Ganguli, 1st Edition, 2018, Cambridge University Press
9. Electronic Principles, A. Malvino, D.J. Bates, 7th Edition, 2018, Tata Mc-Graw Hill Education.
10. Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1994, Mc-Graw Hill. OP-Amps
11. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson

CC-XI: Quantum Mechanics &Applications (32221501)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

After learning the elements of modern physics, students would be poised to learn more advanced topics like how to solve the Schrodinger equation for spherically symmetric potentials. Then, in this course, eigenvalues and eigen functions of the Hamiltonian as well as the orbital angular momentum would be studied. Furthermore, application of Schrodinger equation to various quantum mechanical problems would be taken up. The spin angular momentum of electrons would also be introduced in the course.

Course Learning Outcomes

The Students will be able to learn the following from this course:

- Familiarization with quantum mechanics formulation.
- After an exposition of inadequacies of classical mechanics in explaining microscopic phenomena, quantum theory formulation is introduced through Schrodinger equation.
- The interpretation of wave function of quantum particle and probabilistic nature of its location and subtler points of quantum phenomena are exposed to the student.
- Methods to solve time-dependent and time-independent Schrodinger equation
- Through understanding the behavior of quantum particle encountering a barrier potential, the student gets exposed to solving non-relativistic hydrogen atom, for its spectrum and eigenfunctions.
- Study of influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.
- Angular momentum: Orbital angular momentum and spin angular momentum.
- Bosons and fermions - symmetric and anti-symmetric wave functions.
- Application to atomic systems
- In the laboratory course, with the exposure in computational programming in the computer lab, the student will be in a position to solve Schrodinger equation for ground state energy and wave functions of various simple quantum mechanical one-dimensional and three dimensional potentials.

Unit 1

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of

Wave Function: Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

(12 Lectures)

Unit 2

Time independent Schrodinger equation: Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

(12 Lectures)

Unit 3

General discussion of bound states in an arbitrary potential: continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator: energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.

(10 Lectures)

Unit 4

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground and first excited states; Orbital angular momentum quantum numbers l and m; s, p, d shells.

(10 Lectures)

Unit 5

Atoms in Electric and Magnetic Fields: Electron angular momentum. Angular momentum quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Normal Zeeman Effect: Electron Magnetic Moment and Magnetic Energy.

(8 Lectures)

Unit 6

Many electron atoms: Pauli's Exclusion Principle. Symmetric and Anti-symmetric Wave Functions. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Spin-orbit coupling in atoms-L-S and J-J couplings.

(8 Lectures)

Practical : 60 Hours

Use C/C++/Scilab/Python for solving the following problems based on Quantum Mechanics like:

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2 y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E] \text{where } V(r) = \frac{-e^2}{r}$$

where m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511×10^6 eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2 y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

$$V(r) = \frac{-e^2}{r} e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVÅ)^{1/2}$, m = 0.511×10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$$\frac{d^2 y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

For an harmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100 MeV fm^{-2}, b = 0, 10, 30 MeV fm^{-3}. In these units, cħ = 197.3 MeV fm. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2 y}{dr^2} = A(r)u(r), A(r) = \frac{2\mu}{\hbar^2}[V(r) - E]$$

Where μ is the reduced mass of the two-atom system for the Morse potential

$$V(r) = D\left(e^{-2ar'} - e^{-ar'}\right), r' = \frac{r - r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.
Take: $m = 940 x 10^6$ eV/c^2, D = 0.755501 eV, $\alpha = 1.44$, $r_0 = 0.131349$ Å

Where μ is the reduced mass of the two-atom system for the Morse potential
Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.
Take: $m = 940 x 10^6$ eV/c^2, D = 0.755501 eV, $\alpha = 1.44$, $r_o = 0.131349$ Å

Laboratory based experiments (Optional):

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. Quantum efficiency of CCD

References for Theory:

1. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Ed., 2002, Wiley.
2. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
3. Basic Quantum Mechanics, A. Ghatak, Macmillan, 2009
4. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press
5. Quantum Mechanics: Theory and Applications, (2019), (Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi.

References for Practical:

1. Schaum's outline of Programming with C++. J.Hubbard, 2000,McGraw-Hill Publication
2. An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
3. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
4. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
5. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press

Additional Resources:

1. Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019.
2. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
3. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications, 1966
4. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.

5. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
6. The Principles of Quantum Mechanics, P. A. M. Dirac, Clarendon Press, 2004

CC-XII: Solid State Physics (32221502)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This syllabus begins with introduction to the basic concepts and principles to understand the various properties exhibited by condensed matter, especially solids. These properties depend on the chemical constituents making the particular solid and their arrangement in the crystal. A semi-classical approach is used to introduce various models, from toy model to a higher level, suitable to explain the particular property exhibited by the solid. The syllabus is specifically designed to guide the students to learn how to create a theoretical model for a particular property and appreciate the beauty that lies in these solids through their properties.

Course Learning Outcomes

On successful completion of the module students should be able to

- Elucidate the concept of lattice, crystals and symmetry operations.
- Explain the concepts such as the reciprocal lattice and the Brillouin zone and the dynamics of atoms and electrons in solids.
- Explain diffraction of X-rays by solids to determine the crystal structure.
- Understand the elementary lattice dynamics and its influence on the properties of materials.
- Understand lattice vibrations, phonons and in depth Einstein and Debye theory of specific heat of solids.
- Describe the main features of the physics of electrons in solids.
- Understand the origin of energy bands, and how they influence electronic behavior.
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids.
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability.
- Understand the basics of phase transitions and the preliminary concept and experiments related to superconductivity in solid.
- Apply the gained knowledge to solve problems in solid state physics using relevant mathematical tools.
- To appreciate how matter exhibits such interesting and wonderful properties and communicate the importance of solid state physics in the modern society.
- To carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

Unit 1

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Types of Lattices. Unit Cell, Symmetry and Symmetry Elements. Miller Indices. Reciprocal Lattice. Brillouin Zones. Diffraction of X-rays: single crystal and powder method. Bragg's Law, Laue Condition. Ewalds' construction. Atomic and Geometrical Factor. Simple numerical problem on SC, BCC, FCC.

(14 Lectures)

Unit 2

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3law.

(10 Lectures)

Unit 3

Electrons in Solids: Electrons in metals- Introduction to Drude Model, Density of states (1-D, 2-D, 3-D) (basic idea), Elementary band theory: Kronig Penney model. Band Gap, direct and indirect bandgap. Effective mass, mobility, Hall Effect (Metal and Semiconductor).

(10 Lectures)

Unit 4

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Para- magnetism. Hunds's rule. Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Curie's law. B-H Curve. soft and hard material and Energy Loss Hysteresis.

(9 Lectures)

Unit 5

Dielectric Properties of Materials: Polarization. Local Electric Field in solids. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mossotti Equation. Classical Theory of Electric Polarizability. AC polarizability, Normal and Anomalous Dispersion. Complex Dielectric Constant. Langevin-Debye equation.

(9 Lectures)

Unit 6

Introduction to basics of phase transitions: Landau theory for ferromagnetic materials (No derivation).

(3 Lectures)

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation).

(5 Lectures)

Practical : 60 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the solid state physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 06 experiments from the following:

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
2. To measure the Magnetic susceptibility of solids.
3. To determine the Coupling Coefficient of a piezoelectric crystal.
4. To study the dielectric response of materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique.
6. To determine the refractive index of a dielectric material using SPR technique.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Iron (Fe) using solenoid & determine the energy loss from Hysteresis loop.
9. To measure the resistivity of a semiconductor (Ge) with temperature (up to 150^0C) by four-probe method and determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.
12. Measurement of change in resistance of a semiconductor with magnetic field.

References for Theory:

1. Introduction to Solid State Physics, Charles Kittel, 8^{th}Ed.,2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2^{nd}Ed.,2006, Prentice-Hall of India.
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.
6. Elementary Solid State Physics, M.Ali Omar, 2006, Pearson
7. Solid State Physics, Rita John, 2014, McGraw Hill
8. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

References for Practical:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
4. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
6. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
7. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.
8. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

CC-XIII: Electromagnetic Theory (32221601)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

Electromagnetic theory is a core course in B. Sc. (Honours) Physics curriculum. The course covers Maxwell's equations, propagation of electromagnetic (em) waves in different homogeneous-isotropic as well as anisotropic unbounded and bounded media, production and detection of different types of polarized em waves, general information as waveguides and fibre optics.

Course Learning Outcomes

- Concept of Maxwell Equations, role of displacement current, gauge transformations, scalar and vector potentials, Coulomb and Lorentz gauge, boundary conditions at the interface between different media.
- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
- Understanding of Poynting Theorem and poynting vector.
- Electromagnetic wave propagation in unbounded media: Vacuum, dielectric medium, conducting medium, plasma.
- Electromagnetic wave propagation in bounded media.
- Understand the laws of reflection and refraction and to calculate the reflection and transmission coefficients at plane interface in bounded media.
- Polarization of Electromagnetic Waves: Linear, Circular and Elliptical Polarization. Production as well as detection of waves in laboratory.
- Knowledge of phase retardation plates Quarter-Wave and Half-Wave Plates.
- Babinet Compensator and its uses.
- Experimental verification of Fresnel's theory.
- Understand the features of planar optical wave guide and obtain the Electric field components, Eigen value equations, phase and group velocities in a dielectric wave guide.
- Understand the fundamentals of propagation of electromagnetic waves through optical fibres and calculate numerical apertures for step and graded indices and transmission losses.
- In the laboratory course, the student get an opportunity to perform experiments with Polarimeter, Babinet Compensator, Ultrasonic grating, simple dipole antenna

- To demonstrate principles of Interference, Refraction and diffraction of light using monochromatic sources of light, microwaves.
- Verify the laws of Polarisation for plane polarised light.
- To determine the refractive index of glass and liquid using total internal reflection of light.

Unit 1

Maxwell Equations: Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Poynting's Theorem and Poynting's Vector. Electromagnetic (em) Energy Density. Physical Concept of Electromagnetic Field Energy Density. Momentum Density and Angular Momentum Density.

(12 Lectures)

Unit 2

EM Wave Propagation in Unbounded Media: Plane em waves through vacuum and isotropic dielectric medium: transverse nature, refractive index, dielectric constant, wave impedance. Plane em waves through conducting medium: relaxation time, skin depth, attenuation constant. Wave propagation through dilute plasma: electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth.

(10 Lectures)

Unit 3

EM Waves in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane em waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence)

(10 Lectures)

Unit 4

Polarization of EM Waves: Propagation of em waves in an Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Description of Linear, Circular and Elliptical Polarization. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light

(12 Lectures)

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.

(5 Lectures)

Unit 5

Wave Guides: Planar optical wave guides. Planar dielectric wave guide ($-d/2 < x < d/2$). Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission.

(8 Lectures)

Optical Fibres: Acceptance Angle, Numerical Aperture. Step and Graded Index fibres (Definitions Only). Single and Multiple Mode Fibres.

(3 Lectures)

Practical: 60 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 06 experiments from the following

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify the Stefan`s law of radiation and to determine Stefan's constant.
12. To determine Boltzmann constant using V-I characteristics of PN junction diode.
13. To find Numerical Aperture of an Optical Fibre.
14. To verify Brewster's Law and to find the Brewster's angle.

References for Theory:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Electromagnetic Field and Waves, P. Lorrain and D. Corson, 2nd Ed., 2003, CBS Publisher.
3. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. Problems and solution in Electromagnetics (2015), Ajoy Ghatak, K Thyagarajan & Ravi Varshney.
6. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning

7. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
8. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
9. Electromagnetic field theory fundamentals, B.Guru and H.Hiziroglu, 2015, Cambridge University Press
10. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 2010, Wiley
11. Principle of Optics, M. Born and E. Wolf, 6th Edn., 1980, Pergamon Press
12. Optics, (2017), 6th Edition, Ajoy Ghatak, McGraw-Hill Education, New Delhi

References for Practical:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
4. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
6. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
7. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.
8. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

CC-XIV: Statistical Mechanics
(32221602)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

The Statistical Mechanics deals with the derivation of the macroscopic parameters (internal energy, pressure, specific heat etc.) of a physical system consisting of large number of particles (solid, liquid or gas) from knowledge of the underlying microscopic behavior of atoms and molecules that comprises it. The main objective of this course work is to introduce the techniques of Statistical Mechanics which has applications in various fields including Astrophysics, Semiconductors, Plasma Physics, Bio-Physics etc. and in many other directions.

Course Learning Outcomes

By the end of the course, students will be able to:

- Understand the concepts of microstate, macrostate, ensemble, phase space, thermodynamic probability and partition function.
- Understand the use of Thermodynamic probability and Partition function for calculation of thermodynamic variables. Difference between the classical and quantum statistics
- Understand the combinatoric studies of particles with their distinguishably or indistinguishably nature and conditions which lead to the three different distribution laws e.g. Maxwell-Boltzmann distribution, Bose-Einstein distribution and Fermi-Dirac distribution laws of particles and their derivation.
- Comprehend and articulate the connection as well as dichotomy between classical statistical mechanics and quantum statistical mechanics.
- Learn to apply the classical statistical mechanics to derive the law of equipartition of energy and specific heat.
- Understand the Gibbs paradox, equipartition of energy and concept of negative temperature in two level system.
- Learn to derive classical radiation laws of black body radiation. Wiens law, Rayleigh, Jeans law, ultraviolet catastrophe. Saha ionization formula.
- Learn to calculate the macroscopic properties of degenerate photon gas using BE distribution law, understand Bose-Einstein condensation law and liquid Helium. Bose derivation of Plank's law
- Understand the concept of Fermi energy and Fermi level, calculate the macroscopic properties of completely and strongly degenerate Fermi gas, electronic contribution to specific heat of metals.

- Understand the application of F-D statistical distribution law to derive thermodynamic functions of a degenerate Fermi gas, electron gas in metals and their properties.
- Calculate electron degeneracy pressure and ability to understand the Chandrasekhar mass limit, stability of white dwarfs against gravitational collapse.
- In the laboratory course, the students gets an opportunity to verify Stefan's Law of radiation and determine Stefan's constant.
- Design and perform some experiments to determine Boltzmann' Constant.
- Use Computer simulations to study:
- Planck's Black Body radiation Law and compare with the Wien's Law and Raleigh - Jean's Law in appropriate temperature region.
- Specific Heat of Solids by comparing, Dulong-Petit, Einstein's and Debye's Laws and study their temperature dependence
- Compare the following distributions as a function of temperature for various energies and the parameters of the distribution functions: (i) Maxwell Boltzmann distribution (ii) Bose Einstein distribution (iii) Fermi Dirac distribution

Unit 1

Classical Statistics: Macrostates and Microstates, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur-Tetrode equation. Saha's Ionization Formula. Law of Equipartition of Energy (with proof)– Applications to Specific Heat of gas and solids and its Limitations, Thermodynamic Functions of a Finite Level System, Negative Temperature.

(24 Lectures)

Unit 2

Bose-Einstein Statistics: B-E Distribution law, Thermodynamic functions of a strongly degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.

(12 Lectures)

Unit 3

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly degenerate Fermi Gas, Fermi Energy Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit**.**

(12 Lectures)

Unit 4

Theory of Radiation: Properties of Thermal Radiation and Radiation Pressure. Blackbody Radiation and its spectral distribution. Kirchhoff law. Stefan-Boltzmann law and its Thermodynamic proof. Wien's Displacement law. Wien's Distribution Law. Rayleigh-Jean's Law. Ultraviolet Catastrophe. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation Deduction of Wien's Distribution Law, Rayleigh-Jeans Law, Stefan-Boltzmann Law and Wien's Displacement law from Planck's law.

(12 Lectures)

Practical: 60 Hours

Use C/C++/Scilab/Python other numerical simulations for solving the problems based on Statistical Mechanics like:

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:

a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
b) Study of transient behavior of the system (approach to equilibrium)
c) Relationship of large N and the arrow of time
d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution.

2. Plot the probability of various macrostates in coin-tossing experiment (two level system) versus number of heads with 4, 8, 16 coins etc.

3. Computation of the partition function Z(b) for the systems with a finite number of single particle levels (e.g., 2 level, 3 level etc.) and finite number of non-interacting particles N under Maxwell-Boltzmann/ Fermi-Dirac/Bose Einstein statistics:

a) Study the behavior of Z(b), average energy, C_v, and entropy and its dependence upon the temperature, total number of particles N and the spectrum of single particle energy states.
b) Plot the probability of occupancy of all the states w.r.t. temperature.

4. Plot the Maxwell speed distribution function at different temperatures in a 3-dimension system. Calculate the average speed, root mean square and most probable speed

5. Plot Specific Heat of Solids w.r.t temperature

a) Dulong-Petit law,
b) Einstein distribution function
c) Debye distribution function

6. Plot the following functions with energy at different temperatures
a) Maxwell-Boltzmann distribution
b) Fermi-Dirac distribution
c) Bose-Einstein distribution

7. Plot the distribution of particles w.r.t. energy (dN/de versus e) in 3 Dimensions for
a) Relativistic and non-relativistic bosons both at high and low temperature.
b) Relativistic and non-relativistic fermions both at high and low temperature.

8. Plot Planck's law of Black body radiation w.r.t. wavelength/frequency at different temperatures. Compare it with Rayleigh-Jeans Law and Wien's distribution law for a given temperature.

References for Theory:

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2^{nd} Ed., 1996.
2. Statistical Physics, Berkeley Physics Course, F. Reif, Tata McGraw-Hill, 2008,.
3. Fundamentals of statistical and thermal physics, F. Reif, Waveland Press, 2009.
4. Statistical Mechanics, K. Huang, John Wiley & Sons, 2^{nd} Ed., 1987.
5. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, Narosa, 1986.
6. A treatise on Heat, M.N. Saha and B.N. Srivastava.
7. Statistical Physics, F. Mandl, 2^{nd} Edn., Wiley, 2003.
8. Statistical Mechanics: An Introduction, E. Guha, Alpha Science Intl Ltd, 2007
9. Problems and Solutions on Thermodynamics and Statistical Mechanics, Yung-Kuo Lim (NUS, Singapore), Major American Univ. Ph.D. Qualifying Questions and Solutions – Physics, 1990.
10. Problems in Thermodynamics and Statistical Physics, Peter T. Landsberg, Courier Corporation, 2014.
11. An Introduction to thermal physics: D. Schroeder, Pearson.
12. Introductory Statistical Mechanics, R. Bowley and M. Sanchez, 2^{nd} Edn., Oxford Univ. Press, 2007.

References for Practical:

1. Elementary Numerical Analysis, K.E. Atkinson, 3rdEdn. 2007, Wiley India Edition
2. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2^{nd} Ed., 1996
3. Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
6. Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.

Additional References:

1. Thermal Physics: Kinetic Theory, Thermodynamics and Statistical Mechanics, C.K. Ghosh, R.K. Bansal and S.C. Garg, 2^{nd} Ed, McGraw Hill Education, 2013
2. A Textbook of Statistical Mechanics, S. Chandra and M. K. Sharma, CBS Publishers & Distributors, 2016.
3. Fundamentals of Quantum Mechanics Statistical Mechanics & Solid State Physics, S.P. Kuila, New Central Book Agency (P) Ltd., 2012.

9.2. Discipline Specific Elective-(DSE)

DSE: Experimental Techniques (32227501)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This paper aims to describe the errors in measurement and statistical analysis of data required while performing an experiment. Also, students will learn the working principle, efficiency and applications of transducers & industrial instrument like digital multimeter, RTD, Thermistor, Thermocouples and Semiconductor type temperature sensors.

Course Learning Outcomes

Upon successful completion of the course, students will be able to:

- Learn the measurement systems, errors in measurements and statistical treatment of data.
- About Noise and signal, signal to noise ratio, different types of noises and their identification.
- Concept of electromagnetic interference and necessity of grounding.
- Understand principle of working and industrial applications of various transducers like Electrical, Thermal and Mechanical systems commonly used to measure Temperature and Position in industry.
- Develop an understanding of construction and working of different measuring instruments.
- Develop an understanding of construction, working and use of different AC and DC bridges and its applications.

Unit 1

Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Gaussian distribution.

(7 Lectures)

Signals and Systems: Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise

(3 Lectures)

Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference.

(4 Lectures)

Unit 2

Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems. Generalized perform ance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Qualitative difference between Transducers and sensors. Types of sensors (Physical, Chemical and Biological), Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector.

(21 Lectures)

Unit 3

Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement.

(5 Lectures)

Impedance Bridges and Q-meter: Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge.

(4 Lectures)

Unit 4

Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber with roughing and backing, Mechanical pumps (Rotary and root pumps), Diffusion pump & Turbo Molecular pump, Ion pumps, Pumping speed, throughput, Pressure gauges (Pirani, Penning, ionization, cold cathode).

(16 Lectures)

Practical: 60 Hours

PRACTICAL- DSE LAB: Experimental Techniques Lab

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 06 experiments each from the following

1. Determine output characteristics of a LVDT & measure displacement using LVDT

2. Measurement of Strain using Strain Gauge, level using capacitive transducer, distance using ultrasonic transducer
3. To study the characteristics of a Thermostat and determine its parameters.
4. Calibrate Semiconductor type temperature sensor (AD590, LM35, LM75) and Resistance Temperature Device (RTD).
5. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
6. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2mlength, understanding of importance of grounding using function generator of mV level & an oscilloscope.
7. To design and study the Sample and Hold Circuit.
8. Design and analyze the Clippers and Clampers circuits using junction diode
9. To plot the frequency response of a microphone.
10. To measure Q of a coil and influence of frequency, using a Q-meter.

References

1. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
2. Introduction to Measurements and Instrumentation, A.K. Ghosh, 4th Edition, 2017, PHI Learning Pvt. Ltd.
3. Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
4. Instrumentation Devices and Systems, C.S.Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
5. Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer
6. Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1990, Mc-Graw Hill
7. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M.Sayer and A. Mansingh, 2005, PHI Learning.

DSE: Advanced Mathematical Physics - I (32227502)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

The course is intended to impart the concept of generalized mathematical constructs in terms of Algebraic Structures (mainly Vector Spaces) and Tensors to have in-depth analysis of our physical system.

Course Learning Outcomes

- Demonstration of Algebraic Structures in n-dimension. Application of Vector Spaces & Matrices in the quantum world.
- Learn the basic properties of the linear vector space such as linear dependence and independence of vectors, change of basis, isomorphism and homomorphism, linear transformations and their representation by matrices.
- Learn the basic properties of matrices, different types of matrices viz., Hermitian, skew Hermitian, orthogonal and unitary matrices and their correspondence to physical quantities, e.g, operators in quantum mechanics. They should also learn how to find the eigenvalues and eigenvectors of matrices.
- Learn some basic properties tensors, their symmetric and antisymmetric nature, the Cartesian tensors, the general tensors, contravariant, covariant and mixed tensors and their transformation properties under coordinate transformations, physical examples of tensors such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor etc.
- Learn how to express the mathematical equations for the Laws of Physics in their co-variant forms.
- Learn how to express a mathematical equation concerned with an event compatible with the physical system.
- In the laboratory course, the students are expected to solve the problems using the Scilab/C++ computer language like Multiplication of matrices, Diagonalization of a matrix, Inverse of a matrix, Solutions of differential equations satisfied by different orthogonal polynomials and special function, Determination of wave functions for stationary states as eigenfunctions of Hermitian differential operators and also the energy eigenvalues etc.

Unit 1

Linear Vector Spaces Abstract Systems: Binary Operations and Relations. Introduction to Groups and Fields.
Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.

(12 Lectures)

Unit 2

Matrices, Addition and Multiplication of Matrices: Null Matrices. Diagonal, Scalar and Unit Matrices. Upper- Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Similar Matrices. Trace of a Matrix. Inner Product.

(8 Lectures)

Unit 3

Eigen-values and Eigenvectors: Finding Eigen – values and Eigen vectors of a Matrix. Diagonalization of Matrices. Properties of Eigen-values and Eigen Vectors of Orthogonal, Hermitian and Unitary Matrices. Cayley-Hamiliton Theorem (Statement only). Finding inverse of a matrix using Cayley-Hamiltion Theorem. Use of Matrices in Solving ordinary second order differential equations and Coupled Linear Ordinary Differential Equations of first order. Functions of a Matrix.

(10 Lectures)

Unit 4

Cartesian Tensors: Transformation of Co-ordinates and fundamentals of Tensors. Einstein's Summation Convention. Relation between Direction Cosines. Algebra of Tensors: Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Anti-symmetric Tensor of Order Two and Vectors.

(8 lectures)

Unit 5

Applications of Cartesian Tensors: Vector Calculus using Cartesian Tensors: Scalar and Vector Products of 2, 3, 4 vectors. Gradient, Divergence and Curl of Tensor Fields. Tensor notation of Laplacian operator. Proof of Vector Identities involving scalar and vector products and vector identities involving Del operator using Tensor notation. Isotropic Tensors (Definition only). Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.

(12 lectures)

Unit 6

General Tensors: Transformation of Co-ordinates. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti- symmetric Tensors. Metric Tensor in cartesian, cylindrical, spherical coordinates.

(10 Lectures)

Practical: 60 Hours

PRACTICAL- DSE LAB: Advanced Mathematical Physics-I

Scilab/C^{++}/Python based simulations experiments based on Mathematical Physics problems like (at least 06 experiments)

1. Linear algebra:
- Multiplication of two 3 x 3 matrices.
- Power and Inverse Power methods for finding largest and smallest Eigenvalue and eigenvectors of matrices. QR method e.g.

$$\begin{pmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 3 & 1 & 4 \end{pmatrix}; \begin{pmatrix} 1 & -i & 3+4i \\ +i & 2 & 4 \\ 3-4i & 4 & 3 \end{pmatrix}; \begin{pmatrix} 2 & -i & 2i \\ +i & 4 & 3 \\ -2i & 3 & 5 \end{pmatrix}$$

2. Orthogonal polynomials as eigenfunctions of Hermitian differential operators.
3. Determination of the principal axes of moment of inertia through diagonalization (Matrix can be generated for a given distribution of discrete masses).

4. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc): Using variational principal find the shortest curve between two points. Suggested Physics problem: problem of refraction.
5. Application to solve differential equations for a bound system – Eigen value problem.
6. Application to computer graphics:
   Write operators for shear, strain, two dimensional rotational problems, Reflection, Translation etc. Plot old and new coordinates.
7. Lagrangian formulation in classical mechanics with constraints.
8. Vector space of wave functions in Quantum Mechanics: Position and Momentum differential operators and their commutator, wave functions for stationary states as eigenfunction

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Note: Students opting for Linear algebra and Tensor analysis as one option in DSE cannot opt Advanced mathematical physics-I course as second option.

References for Theory:

1. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
2. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber and F.E.Harris,1970, Elsevier.
3. Theory and Problems of Linear Algebra, Seymour Lipschutz, 1987, McGraco-Hill Inc.
4. Theory and Problems of Vector Analysis and an introduction to Tensor Analysis, Murray R. Spiegel, 1974, McGraw Hill, Inc.
5. Elementary Linear Algebra, Applications Version, Howard Anton and Chris Rorres, Wiley Student edition.
6. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press.
7. Introduction to Matrices & Linear Transformations, D.T.Finkbeiner,1978, Dover Pub.
8. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole

References for Practical:

1. An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).
2. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer, ISBN: 978-3319067896
3. Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
4. Documentation at the Python home page, https://docs.python.org/3/
5. Learning Scientific Programming with Python, Christian Hill, Cambridge University Press (2016)

Additional Resources:

1. Introduction to Vectors and Tensors, Ray M Bowen, C -C Wang, Dover Publications (2009)
2. An Introduction to Linear Algebra and Tensors, M A Akivis, V V Goldberg, Richard and Silverman, Dover Publications (2012)
3. Computational Problems for Physics: With Guided Solutions Using Python, Rubin H. Landau, Manuel José Páez, CRC Press (2018).
4. https://arxiv.org/pdf/1703.09738.pdf
5. 'The C++ Programming Language, Bjarne Stroustrup, Addison-Wesley Professional (2013)
6. Numerical Recipes in C^{++}: The Art of Scientific Computing, W.H. Press et.al., 2ndEdn., Cambridge University Press (2013).
7. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition

DSE: Nuclear and Particle Physics (32227504)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

The objective of the course is to impart the understanding of subatomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches of Physics and application to society. The phenomenology and experimental foundations of nuclear and particle physics are explored in this course. Emphasis is on the fundamental forces and particles, as well as composites. The students will learn how cutting-edge research is trying to answer the big questions about our universe. In addition they will learn how new ideas find their way from fundamental research to specific applications that have practical value. They will understand the relevance of everything from development and construction of a nuclear physics experimental equipment including accelerators and detectors, and eventually their use in order to study the structure of nucleus. By the end of the course, the students would be able to explain the basic properties of nuclei, classify elementary particles into hadrons and leptons, and understand how hadrons are constructed from quarks. They will also learn about flavor quantum numbers such as isospin, strangeness, etc. The course will focus on the developments of problem based skills.

Course Learning Outcomes

- To be able to understand the basic properties of nuclei as well as knowledge of experimental determination of the same, the concept of binding energy, its various dependent parameters, N-Z curves and their significance
- To appreciate the formulations and contrasts between different nuclear models such as Liquid drop model, Fermi gas model and Shell Model and evidences in support.
- Knowledge of radioactivity and decay laws. A detailed analysis, comparison and energy kinematics of alpha, beta and gamma decays.
- Familiarization with different types of nuclear reactions, Q- values, compound and direct reactions.
- To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter and neutron interaction with matter. Through the section on accelerators students will acquire knowledge about Accelerator facilities in India along with a comparative study of a range of detectors and accelerators which are building blocks of modern day science.
- It will acquaint students with the nature and magnitude of different forces, particle interactions, families of sub- atomic particles with the different conservation laws, concept of quark model.
- The acquired knowledge can be applied in the areas of nuclear medicine, medical physics, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.

Unit 1

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density, matter density (experimental determination of each), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/Z plot, angular momentum, parity, magnetic moment, electric moments.

(10 Lectures)

Unit 2

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons), Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure and the basic assumptions of shell model.

(11 Lectures)

Unit 3

Radioactivity decay: Decay rate and equilibrium (Secular and Transient) (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains. (b) β- decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion.

(10 Lectures)

Unit 4

Nuclear Reactions: Types of Reactions, units of related physical quantities, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

(8 Lectures)

Unit 5

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter (photoelectric effect, Compton scattering, pair production), neutron interaction with matter.

(9 Lectures)

Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

(9 Lectures)

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons (Principal, construction, working, advantages and disadvantages).

(7 Lectures)

Unit 6

Particle physics: Particle interactions (concept of different types of forces), basic features, Cosmic Rays, types of particles and its families, Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness) concept of quark model, color quantum number and gluons.

(11 Lectures)

References

1. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
2. Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
3. Concepts of Nuclear Physics by B L Cohen, Tata McGraw Hill Publication, 1974.
4. Introductory Nuclear Physics by K S Krane, Wiley-India Publication, 2008.
5. Nuclear Physics: principles and applications by J Lilley, Wiley Publication, 2006.
6. Physics and Engineering of Radiation Detection by S N Ahmed, Academic Press Elsevier, 2007.
7. Radiation detection and measurement, G F Knoll, John Wiley & Sons, 2010.
8. Techniques for Nuclear and Particle Physics experiments by WR Leo, Springer, 1994.
9. Introduction to Modern Physics by Mani & G K Mehta, Affiliated East-West Press, 1990.
10. Introduction to elementary particles by D J Griffiths, Wiley, 2008.
11. Modern Physics by R A Serway, C J Moses and C A Moyer, 3rd edition, Thomson Brooks Cole, 2012.
12. Modern Physics for Scientists and Engineers by S T Thornton and A Rex, 4th edition,

Cengage Learning, 2013.
13. Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education, 2009.
14. Modern Physics by G Aruldhas and P Rajagopal. PHI Learning Pvt. Ltd., 2016.

Books for Numericals:

1. Schaum's Outline of Modern Physics, McGraw-Hill, 1999.
2. Schaum's Outline of College Physics, by E. Hecht, 11th edition, McGraw Hill, 2009.
3. Modern Physics by K Sivaprasath and R Murugeshan, S Chand Publication, 2010.

Additional Resources:

1. Nuclear Physics "Problem-based Approach" Including MATLAB by Hari M. Aggarwal, PHI Learning Pvt. Ltd. (2016).

DSE: Physics of Devices and Communication (32227505)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This paper is based on advanced electronics which covers the devices such as UJT, JFET, MOSFET, CMOS etc. Process of IC fabrication is discussed in detail. Digital Data serial and parallel Communication Standards are described along with the understanding of communication systems.

Course Learning Outcomes

At the end of this course, students will be able to develop following learning outcomes:

- Students will develop the basic knowledge of semiconductor device physics and electronic circuits along with the practical technological considerations and applications.
- They will be able to understand the operation of devices such as UJT, JFET, MOS, various bias circuits of MOSFET, Charge coupled Devices and Tunnel Diode.
- Students will learn to analyze MOSFET circuits and develop an understanding of MOSFET I-V characteristics and the allowed frequency limits.
- Another objective of this paper is to introduce students with the IC fabrication technology involving the process of diffusion, implantation, oxidation and etching with an emphasis on photolithography and electron-lithography.

- Students will learn to apply concepts for the regulation of power supply by developing an understanding of various kinds of RC filters classified on the basis of allowed range of frequencies.
- Students will learn basic principles of phase locked loop (PLL) and understand its operation.
- They will gain an understanding of Digital Data serial and parallel Communication Standards. Knowledge of USB standards and GPIB.
- Also, students will understand different blocks in communication system, need of modulation, modulation processes and different modulation schemes.

Unit 1

Devices: Characteristic and small signal equivalent circuits of UJT and JFET. Metal-semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO2-Si based MOS, C-V characteristics of MOS, MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices.

(17 Lectures)

Unit 2

Processing of Devices: Basic process flow for IC fabrication. Crystal plane and orientation. Diffusion and implantation of dopants. Passivation. Oxidation Technique for Si. Contacts and metallization technique. Wet etching. Dry etching (RIE). Positive and Negative Masks. Photolithography. Electron-lithography, Basic idea of SSI, MSI, LSI, VLSI and USI.

(14 Lectures)

Unit 3

RC Filters: Passive-Low pass and High pass filters, Active (1st order butterworth) -Low Pass, High Pass, Band Pass and band Reject Filters.

(3 Lectures)

Phase Locked Loop (PLL): Basic Principles, Phase detector (XOR and edge triggered), Voltage Controlled Oscillator (Basics, varactor). Lock and capture. Basic idea of PLL IC (565 or 4046).

(6 Lectures)

Digital Data Communication Standards: Serial Communications: RS232, Handshaking, Implementation of RS232 on PC, Universal Serial Bus (USB), USB standards, Types and elements of USB transfers. Parallel communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. Basic idea of sending data through a COM port.

(5 Lectures)

Unit 4

Introduction to communication systems: Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. Frequency modulation and demodulation, basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK.

(15 lectures)

Practical: 60 Hours

PRACTICAL- DSE LAB: Physics of Devices and Communication

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 06 experiments each from section-A and section-B:

Section-A:

1. To design a power supply using bridge rectifier and study effect of C-filter.
2. To design the active Low pass and High pass filters of given specification.
3. To design the active filter (wide band pass and band reject) of given specification.
4. To study the output and transfer characteristics of a JFET.
5. To design a common source JFET Amplifier and study its frequency response.
6. To study the output characteristics of a MOSFET.
7. To study the characteristics of a UJT and design a simple Relaxation Oscillator.
8. To design an Amplitude Modulator using Transistor.
9. To design PWM, PPM, PAM and Pulse code modulation using ICs.
10. To design an Astable multivibrator of given specifications using transistor.
11. To study a PLL IC (Lock and capture range).
12. To study envelope detector for demodulation of AM signal.
13. Study of ASK and FSK modulator.
14. Glow an LED via USB port of PC.
15. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

Section-B: SPICE/MULTISIM simulations for electronic circuits and devices

1. To verify the Thevenin and Norton Theorems.
2. Design and analyze the series and parallel LCR circuits
3. Design the inverting and non-inverting amplifier using an Op-Amp of given gain
4. Design and Verification of op-amp as integrator and differentiator
5. Design the 1st orderactive low pass and high pass filters of given cutoff frequency
   (i) Design a Wein`s Bridge oscillator of given frequency.
   (ii)Design clocked SR and JK Flip-Flop`s using NAND Gates
   (iii) Design 4-bit asynchronous counter using Flip-Flop ICs
   (iv) Design the CE amplifier of a given gain and its frequency response.
   (v)10.Design an Astable multivibrator using IC555 of given duty cycle.

References

1. Physics of Semiconductor Devices, S.M.Sze and K.K.Ng, 3rd Edition 2008, John Wiley & Sons
2. Op-Amps & Linear Integrated Circuits, R.A.Gayakwad,4 Ed. 2000, PHI Learning Pvt. Ltd
3. Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
4. Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
5. Introduction to Measurements & Instrumentation, A.K.Ghosh, 4th Edition, 2017, PHI Learning
6. Semiconductor Physics and Devices, D.A. Neamen, 2011, 4th Edition, McGraw Hill
7. PC based instrumentation; Concepts and Practice, N. Mathivanan, 2007, Prentice-Hall of India
8. Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller,1994, Mc-Graw Hill
9. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
10. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
11. Introduction to PSPICE using ORCAD for circuits& Electronics, M.H.Rashid,2003, PHI Learning.

DSE: Astronomy and Astrophysics (32227506)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

This DSE paper for Physics Hons students is designed to provide students with the basic knowledge about the theory and techniques of observational astronomy and physics of the astrophysical phenomenon. This course follows the tradition of theoretical rigour and comprehensiveness of Physics Hons course of the University of Delhi. It applies theoretical concepts and mathematical techniques Physics Hons students have learnt in their earlier courses to astronomical and astrophysical phenomenon.

Course Learning Outcomes

After this course students will be familiar with essential features and techniques of astronomy, and will understand how laws of physics are applied to astrophysical phenomenon. Students will also gain an understanding of the latest developments in the field of astronomy and astrophysics. After this course students will be well equipped to take advanced level post graduate courses in astronomy and astrophysics. They will also be prepared to do student research level internships at research institutes.

During this course students will specifically learn:

- Significance of astronomical scales, basic concepts of positional astronomy like astronomical coordinate systems, transformations between different astronomical coordinate systems, and astronomical methods to determine distances, and time, and temperature and radius of a star.
- Basic parameters of stars like brightness, radiant flux, luminosity, magnitude, spectral classification. H-R diagram
- About various types of telescopes and telescope mountings.
- Understand the physics of the Sun, including solar MHD, Alfven's theorem, chromosphere, corona, and solar activity
- Understand the physics of stars, hydrostatic equilibrium, temperature gradient, stellar energy sources
- Acquire basic knowledge of the Milky Way, its structure, rotation, nucleus and Oort's constants
- Learn about the large scale structure of the universe, cosmic distance ladder, Hubble Law, Newtonian cosmology and Friedman models.

Unit 1

Introduction to Astronomy and Astronomical Scales: Overview of the Night Sky, Diurnal and Yearly motions of the Sun, Stars and Constellations. Size, Mass, Density and Temperature of Astronomical Objects. Basic concepts of Positional Astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Horizon System, Equatorial System, Conversion of Coordinates. Rising and Setting Times, Measurement of Time, Side real Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Astronomical Time Systems (LMT, UT, UTC).

(16 Lectures)

Unit 2

Basic Parameters of Stars: Determination of Distance by Parallax Method; Proper Motion, Brightness, Radiant Flux and Luminosity, Apparent andAbsolute Magnitude Scales, Distance Modulus, Extinction, Determination of Temperature and Radius of a star; Stellar Spectra,Atomic Spectra Revisited, Introduction to Boltzman and Saha Equations, Balmer Lines of H, H and K lines of Ca, Spectral Types and Their Temperature Dependence, Black Body Approximation, Luminosity Classification, H R Diagram and Relations Between Stellar Parameters.

(16 Lectures)

Unit 3

Observational Tools and Physical Principles: Observing through the atmosphere (Scintillation, Seeing , Atmospheric Windows and Extinction) Basic Optical Definitions for Telescopes: Magnification, Light Gathering Power, Limiting magnitude, Resolving Power, Diffraction Limit. Optical and Radio Telescopes, Current Indian Observatories. Virial theorem for N particle systems, applications in astrophysics. Systems in Thermodynamic Equilibrium, Equations for Hydrostatic equilibrium, Mean Molecular Weight of stellar gas, Stellar Energy Sources.

(16 Lectures)

Unit 4

Sun and the Milky Way: Solar Parameters, Sun's Internal Structure, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Solar Magneto-Hydrodynamics, Alfven's Theorem. Basic Structure and Properties of the Milky Way, Nature of rotation of the Milky Way (Differential rotation of the Galaxy and Oort Constants, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Properties of and Around the Galactic Nucleus.

(15 Lectures)

Unit 5

Cosmology: Standard Candles (Cepheids and SNe Type1a), Cosmic Distance Ladder, Olbers Paradox, Hubble Expansion, Cosmological Principle, Newtonian Cosmology and Friedmann Models

(12 Lectures)

References

1. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
2. Astrophysics Stars and Galaxies K D Abhyankar, Universities Press
3. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.
5. The Physical Universe: An Introduction to Astronomy, F H Shu, University Science Books
6. Baidyanath Basu, An introduction to Astrophysics, Second printing, Prentice - Hall of India Private limited, New Delhi,2001.
7. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
8. Explorations: Introduction to Astronomy, Thomos Arny and Stephen Schneider, 2014, 7th edition, McGraw Hill
9. Principles of Stellar Dynamics, S Chandrasekhar, Dover Books

DSE: Atmospheric Physics (32227507)
Credit:06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical: 60 Hours

Course Objective

This paper aims to describe the characteristics of earth's atmosphere and also its dynamics.

Course Learning Outcomes

- Good knowledge of Earth's atmosphere, its composition, effective temperature, Greenhouse effect. Hydrostatic equation and atmospheric thermodynamics. Local winds, clouds, fog, monsoon, cyclones, sea breeze and land breeze and thunderstorms etc.
- Essential knowledge of the instruments of meteorological observation, meteorological processes and systems.
- Understanding atmospheric dynamics, fundamental forces, conservation laws, rotating coordinate system and equations of motion. Circulation, vorticity, various types of circulations, atmospheric oscillations: biannual, annual and semi-annual oscillations.
- Understanding atmospheric waves. Surface water waves, accoustic waves, buoyancy waves, atmospheric gravity waves (AGW) and its propagation in non-homogeneous medium, Lamb and Rossy waves and their propagation in 3-dimension. Wave absorption and non linear effects.
- Skills to use atmospheric Radar and Lidar to study atmospheric phenomenon, basic knowledge of Radars and Lidars including Radar equation and signal processing. Develop numerical skills to do data analysis from Radar and Lidar.
- Knowledge of the classification and properties of aerosols, their concentrations and size distribution. Production and removal of aerosols. Radiative and health effects and observation techniques for aerosols.
- Understanding the absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Boyer-Lambert law, optical phenomenon in atmosphere. Basics of radiometry.
- In the laboratory course through computer simulations students will learn Atmospheric wave using Dispersion relations, Kelvin waves, Rossby waves and Mountain waves.

(i) Offline and if possible online processing of RADAR data: VHF RADAR, X-band RADAR, UHF RADAR.
(ii) Offline and Online processing of LIDAR data
(iii) Study of Radiosonde data and its interpretation in terms of the atmospheric parameters
(iv) Interpretation of the satellite data using radio Occultation technique
(v) Time Series Analysis of Temperature using long term data and implications for climate change.

Unit 1

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms.

(12 Lectures)

Unit 2

Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics.

(12 Lectures)

Unit 3

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration.

(12 Lectures)

Unit 4

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.

(12 Lectures)

Unit 5

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars.

(12 Lectures)

Practical : 60 Hours

PRACTICAL- DSE LAB: Atmospheric Physics

Scilab/C ++ based simulations experiments based on Atmospheric Physics problems like
At least 05 Experiments from the following

1. Numerical Simulation for atmospheric waves using dispersion relations
   a. Atmospheric gravity waves (AGW)
   b. Kelvin waves
   c. Rossby waves, and mountain waves
2. Offline and online processing of radar data
   a. VHF radar,
   b. X-band radar, and
   c. UHF radar
3. Offline and online processing of LIDAR data
4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.
5. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique
6. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change
7. PM 2.5 measurement using compact instruments
8. Field visits to National center for medium range weather forecasting, India meteorological departments, and ARIES Nainital to see onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

References

1. Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3 rd edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

DSE: Biological Physics (32227508)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

- To familiarize the students with the basic facts and ideas of biology from a quantitative perspective.
- To show them how ideas and methods of physics enrich our understanding of biological systems at diverse length and time scales.
- To give them a flavour of the interface between biology, chemistry, physics and mathematics.

Course Learning Outcomes

After completing this course, students will

- Know basic facts about biological systems, including single cells, multicellular organisms and ecosystems from a quantitative perspective.
- Gain familiarity with various biological processes at different length and time scales, including molecular processes, organism level processes and evolution.
- Be able to apply the principles of physics from areas such as mechanics, electricity and magnetism, thermodynamics, statistical mechanics, and dynamical systems to understand certain living processes.
- Gain a systems level perspective on organisms and appreciate how networks of interactions of many components give rise to complex behavior.
- Perform mathematical and computational modelling of certain aspects of living systems.

Unit 1

Overview: The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Allometric scaling laws.

(6 Lectures)

Unit 2

Molecules of life: Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling. Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell. Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways to be studied analytically and computationally.

(18 Lectures)

Unit 3

Molecular motion in cells: Random walks and applications to biology: Diffusion; models of macromolecules. Entropic forces: Osmotic pressure; polymer elasticity.
Chemical forces: Self assembly of amphiphiles. Molecular motors: Transport along microtubules. Flagellar motion: bacterial chemotaxis.

(22 Lectures)

Unit 4

The complexity of life: At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Metabolic, regulatory and signaling networks in cells. Dynamics of metabolic networks; the stoichiometric matrix. The implausibility of life based on a simplified probability estimate, and the origin of life problem. At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cellular differentiation and development. Brain structure: neurons and neural networks. Brain as an information processing system. At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self- sustaining ecosystems.

(20 Lectures)

Unit 5

Evolution: The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.

(9 Lectures)

References

1. Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman &Co, NY, 2004)
2. Physical Biology of the Cell (2nd Edition); Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)
3. An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)
4. Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition).

DSE: Embedded systems - Introduction to Microcontroller (32227518)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This paper gives a review of microprocessor and introduces microcontroller 8051.
- Here, students will learn about the 8051 I/O port programming, various addressing modes, Timer and counter programming, Serial port programming with and without interrupt and interfacing 8051 microcontroller to peripherals.

Course Learning Outcomes

This is a course to familiarize/ introduce students to designing and developing embedded systems. It provides the students with an introductory coverage of embedded systems. The learning outcomes of the course are:

- Knowledge of the major components that constitute an embedded system.
- Understand what is a microcontroller, microcomputer embedded system.
- Description of the architecture of a 8051 microcontroller.
- Write simple programs for 8051 microcontroller in C language.
- Understand key concepts of 8051 microcontroller systems like I/O operations, interrupts, programming of timers and counters.
- Interfacing of 8051 microcontroller with peripherals
- Understand and explain concepts and architecture of embedded systems
- Implement small programs to solve well-defined problems on an embedded platform.
- Develop familiarity with tools used to develop an embedded environment
- Learning to use the Arduino Uno (an open source microcontroller board) in simple applications.

Unit 1

Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems.

(4 Lectures)

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions.

(12 Lectures)

Unit 2

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of 8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation.

(4 Lectures)

Programming: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming in C: for time delay & I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions.

(12 Lectures)

Unit 3

Timer and counter programming: Programming 8051 timers, counter programming.

(3 Lectures)

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051.

(6 Lectures)

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing.

(2 Lectures)

Unit 4

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging.

(3 Lectures)

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry.

(8 Lectures)

Unit 5

Introduction to Arduino: Pin diagram and description of Arduino UNO. Basic programming and applications.

(6 Lectures)

Practical : 60 Hours

PRACTICALS- DSE LAB: Embedded systems - Introduction to Microcontroller

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

8051 microcontroller-based Programs and experiments (at least 06 experiments):

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's .
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
9. To toggle '1234' as '1324' in the seven segment LED display.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.
12. Arduino based programs and experiments:
13. Make a LED flash at different time intervals.
14. To vary the intensity of LED connected to Arduino
15. To control speed of a stepper motor using a potential meter connected to Arduino
16. To display "PHYSICS" on LCD/CRO.

References

1. Embedded Systems: Architecture, Programming & Design, Raj Kamal, 2008,Tata McGraw Hill
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.
3. Microcontrollers in practice, I.Susnea and M.Mitescu, 2005, Springer.
4. Embedded Systems & Robots, Subrata Ghoshal, 2009, Cengage Learning
5. Introduction to embedded system, K.V. Shibu, 1st edition, 2009, McGraw Hill
6. Embedded Microcomputer systems: Real time interfacing, J.W.Valvano 2011, Cengage Learning
7. Microprocessors and Microcontrollers, Krishna Kant, 2nd Edition, 2016. PHI learning Pvt. Ltd.
8. Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.

DSE: Linear Algebra and Tensor Analysis (xxx3)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

The course is intended to impart the concept of generalized mathematical constructs in terms of Algebraic Structures (mainly Vector Spaces) and Tensors to have in-depth analysis of our Physical System.

Course Learning Outcomes

- Demonstration of Algebraic Structures in n-dimension. Application of Vector Spaces & Matrices in the quantum world.
- Learn the basic properties of the linear vector space such as linear dependence and independence of vectors, change of basis, isomorphism and homomorphism, linear transformations and their representation by matrices.
- Learn the basic properties of matrices, different types of matrices viz., Hermitian, skew Hermitian, orthogonal and unitary matrices and their correspondence to physical quantities, e.g, operators in quantum mechanics. They should also learn how to find the eigenvalues and eigenvectors of matrices.
- Learn some basic properties tensors, their symmetric and antisymmetric nature, the Cartesian tensors, the general tensors, contravariant, covariant and mixed tensors and their transformation properties under coordinate transformations, physical examples of tensors such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor etc.
- Learn how to express the mathematical equations for the Laws of Physics in their co-variant forms.
- Learn how to express a mathematical equation concerned with an event compatible with the physical system.

Unit 1

Vector Space and Subspace: Binary Operations, Groups, Rings & Fields, Vector Space & Subspace, Examples of Vector Spaces, Euclidean Vector Spaces: Length and Distance in Rn, Matrix notation for vectors in Rn,Four Subspaces associated with a Matrix

(8 Lectures)

Basic and Dimension: Linear Dependence and Independence of vectors, Spanning a Space, Basis and Dimensions, Rank and Nullity of a Matrix, Examples from Real Function Space and Polynomial Space, Orthogonal Vectors and Subspaces, Orthogonal Basis, Gram-Schmidt process of generating an Orthonormal Basis

(4 Lectures)

Unit 2

Linear Transformation: Function and Mapping, General Linear Transformations and Examples, Kernel and Range of a Matrix Transformation, Homomorphism and Isomorphism of vector space, Singular and Non-singular Mapping/Transformations, Algebra of Linear operator.

(8 Lectures)

Invertible operators: Identity Transformation, Matrices and Linear Operators, Matrix Representation of a Linear transformation and change of basis, Similarity.

(5 Lectures)

Unit 3

Matrices and Matrix Operations: Addition and Multiplication of Matrices, Null Matrices, Diagonal, Scalar and Unit Matrices, Upper Triangular and Lower-Triangular Matrices, Transpose of a Matrix, Symmetric and Skew-Symmetric Matrices, Matrices for Networks, Matrix Multiplication and System of Linear Equations, Augmented Matrix, Echelon Matrices, Gauss Elimination and Gauss-Jordan Elimination, Inverse of a Matrix, Elementary Matrix, Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices, Determinants, Evaluating Determinants by Row Reduction, Properties of Determinants, Adjoint of a Matrix, Singular and Non-Singular matrices, Orthogonal Matrix, Unitary Matrices, Trace of a Matrix, Inner Product.

(12 Lectures)

Unit 4

Eigen-values and Eigenvectors: Finding Eigen-values and Eigen vectors of a Matrice. Diagonalization of Matrices. Properties of Eigen-values and Eigen Vectors of Orthogonal, Hermetian and Unitary Matrices. Cayley- Hamiliton Theorem (Statement only).Finding inverse of a matrix using Cayley-Hamiltion Theorem. Use of Matrices in Solving Coupled Linear Ordinary Differential Equations of first order. Functions of a Matrix.

(8 Lectures)

Unit 5

Cartesian Tensor: Transformation of co-ordinates, Einstein's summation convention, Relation between Direction Cosines, Tensors, Algebra of Tensors: Sum, Difference and Product of Two Tensors. Contraction, Quotient Law of Tensors, Symmetric and Anti-symmetric Tensors, Invariant Tensors: Kronecker and Alternating Tensors, Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and calculus using Cartesian Tensors: Scalar and Vector Products of 2, 3, 4 vectors. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor.Generalized Hooke's Law.

(16 Lectures)

Unit 6

Geometrical Applications: Equation of a line, Angle between lines. Projection of a line on another line. Condition for two lines to be coplanar. Foot of the Perpendicular from a Point on a Line, Rotation Tensor, Isotropic tensors (definition only), Moment of Inertia tensors .

(4 Lectures)

General Tensors: Transformation of Co-ordinates, Contravariant & Covariant Vectors, Contravariant, Covariant and Mixed Tensors, Kronecker Delta and Permutation Tensors, Algebra of Tensors, Sum, Difference & Product of Two Tensors, Contraction, Quotient Law of Tensors, Symmetric and Anti- symmetric Tensors, Metric Tensor.

(10 Lectures)

References

9. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
10. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber and F.E.Harris,1970, Elsevier.
11. Theory and Problems of Linear Algebra, Seymour Lipschutz, 1987, McGraco-Hill Inc.
12. Theory and Problems of Vector Analysis and an introduction to Tensor Analysis, Murray R. Spiegel, 1974, McGraw Hill, Inc.
13. Elementary Linear Algebra, Applications Version, Howard Anton and Chris Rorres, Wiley Student edition.
14. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press.
15. Introduction to Matrices & Linear Transformations, D.T. Finkbeiner,1978, Dover Pub.
16. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole

DSE: Nano Materials and Applications (32227612)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

The syllabus introduces the basic concepts and principles to categories and understand nanomaterial. Various nanomaterial synthesis/growth methods and characterizations techniques are discussed to explore the field in detail. The effect of dimensional confinement of charge carries on the electrical, optical and structural propertie are discussed. Interesting experiments which shape this filed like conductance quantization in 2DEG (Integer Quantum Hall Effect) and coulomb blockade are introduced. The concept of micro- and nano- electro mechanical systems (MEMS and NEMS) and important applications areas of nanomaterials are discussed.

Course Learning Outcomes

On successful completion of the module students should be able to

- Explain the difference between nanomaterials and bulk materials and their properties.
- Explain various methods for the synthesis/growth of nanomaterials including top down and bottom up approaches.
- Explain the role of confinement on the density of state function and so on the various properties exhibited by nanomaterials compared to bulk materials.
- Explain the various characterization tools required to study the structural, optical and electrical properties of nanomaterials.
- Analyze the data obtained from the various characterization techniques: X-ray diffraction, electron microscopy, Atomic Force Microscopy and Scanning Tunneling Microscopy.
- Explain the concept of Quasi-particles such as excitons and how they influence the optical properties.
- Explain the direct and indirect bandgap semiconductors, radiative and non-radiative processes and the concept of luminescence.
- Explain the structure of 2DEG system and its importance in quantum transport experiments.
- Explain the Interger Quantum Hall Effect and the concept of Landau Levels, and edge states in conductance quantization.
- Explain the conductance quantization in 1D structure and its difference from the 2DEG system.
- Explain the necessary and sufficient conditions required to observe coulomb blockade, single electron transistor and the scope of these devices.
- Explain how MEMS and NEMS devices are produced and their applications.
- Explain why nanomaterials exhibit properties which are sometimes very opposite, like magnetic, to their bulk counterparts.
- In the Lab course the student will synthesize nanoparticles by different chemical routs and characterize them in the laboratory using the different techniques he has learnt in the theory. He will also carry out thin film preparation and prepare capacitors and evaluate its performance. He also expected to fabricate a PN diode and study its I-V characteristics.

Unit 1

NANOSCALE SYSTEMS: Density of states (3D, 2D, 1D,0D),Length scales in physics, Nanostructures: 1D, 2D and 3D confined nanostructures (thin films, nanowires, nanorods, nanodots), Schrodinger equation- Infinite potential well, potential step, potential box,Band structure and density of states of materials at nanoscale (Quantitative for 3D, 2D, 1D, 0D), Size Effects in nano systems, Applications of quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences on electronic and optical properties. Numerical problems based on above topics.

(14 Lectures)

Unit 2

SYNTHESIS OF NANOSTRUCTURE MATERIALS (Qualitative): Top down and Bottom up approach, Photolithography. Ball milling. Spin coating, Vacuum deposition: Physical vapor deposition (PVD): Thermal evaporation, Sputtering, Pulsed Laser Deposition (PLD), electric arc deposition for CNT, C_{60}, grapheme, Chemical vapor deposition (CVD). Preparation through colloidal methods (Metals, Metal Oxide nanoparticles), Molecular Beam Epitaxy (MBE) growth of quantum dots.

(5 Lectures)

Unit 3

CHARACTERIZATION: Structure and Surface morphology: X-Ray Diffraction (XRD). Scanning Electron Microscopy (SEM). Transmission Electron Microscopy (TEM).Atomic Force Microscopy (AFM).Scanning Tunneling Microscopy (STM).
Spectroscopy: Working principle of UV-Vis spectroscopy, IR Spectroscopy, Raman and Photoluminescence Spectroscopy and study the size dependent properties using these techniques.

(11 Lectures)

Unit 4

OPTICAL PROPERTIES: Quasi-particles and collective excitations (Qualitative idea).Quantitative treatment of excitons, Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of nanoparticles as a function of size, defects and impurities: deep level and surface defects. Numerical problems based on above topics.

(10 Lectures)

Unit 5

ELECTRON TRANSPORT: time and length scales of electrons in solids, Carrier transport in nanostructures: diffusive and ballistic transport, Charging effect, Coulomb blockade effect. Single electron transfer devices (no derivation).Conductance quantization: 2DEG in GaAs and integer quantum hall effect (Quantitative), conductance quantization in 1D structures using split gate in 2DEG (no derivation).Numerical problems based on above topics.

(14 Lectures)

Unit 6

APPLICATIONS (Qualitative): Applications of nanoparticles, quantum dots, nanowires and thinfilms for photonic devices (LED, solar cells). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructurelasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots-magnetic data storage.Micro Electromechanical Systems (MEMS), NanoElectromechanical Systems (NEMS).

(6 Lectures)

Practical : 60 Hours

PRACTICALS- DSE LAB: Nano Material and Applications Lab

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the nano physics lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

At least 06 experiments from the following:

1. Synthesis of metal (Au/Ag)nanoparticles by chemical route and study its optical absorption properties.
2. Synthesis of semiconductor (CdS/ZnO/TiO2/Fe2O3etc) nanoparticles and study its XRD and optical absorption properties as a function of time.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. Analysis of XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on the color of nanomaterials.
    (i) To prepare composite of CNTs with other materials.
    (ii) Growth of quantum dots by thermal evaporation.
    (iii)Prepare a disc of ceramic of a compound and study its XRD.
    (iv)Fabricate a thin film of nanoparticles by spin coating (or chemical route) andstudy its XRD and transmittance spectra in UV-Visible region.
    (v) Prepare a thin film capacitor and measure capacitance as a function oftemperature or frequency.
    (vi) Fabricate a PN junction diode by diffusing Al over the surface of N-type Si/Geand study itsV-I characteristic.
    (vii) Fabricate thin films (polymer, metal oxide) using electro-deposition
    (viii) To study variation of resistivity or sheet resistance with temperature of the fabricated thin films using four probe method.

References for Theory:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt.Lt..
2. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition(2011) (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
4. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
5. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).
6. Introductory Nanoscience by Masaru Kuno, (2012) Garland science Taylor and Francis Group
7. Solid State Physics by J. R. Hall and H. E. Hall, 2nd edition (2014) Wiley·
8. Electronic transport in mesoscopic systems by Supriyo Datta (1997) Cambridge University Press.
9. Fundamentals of molecular spectroscopy by C. N. Banwell and E. M. McCASH, 4th edition, McGrawHill. Reference Books for Practicals:
10. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt.Ltd..
11. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company)
12. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).

Additional Resources:

1. Quantum Transport in semiconductor nanostructures by Carla Beenakker and HenK Van Houten (1991) (available at arXiv: cond-mat/0412664) open source
2. Sara cronewett Ph.D. thesis (2001).

DSE: Communication System (32227613)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This paper aims to describe the concepts of electronics in communication.
- Communication techniques based on Analog Modulation, Analog and digital Pulse Modulation including PAM, PWM, PPM, ASK, PSK, FSK are described in detail.
- Communication and Navigation systems such as GPS and mobile telephony system are introduced.

Course Learning Outcomes

At the end of this course, students will be able to develop following learning outcomes:

- This paper aims to describe the concepts of electronics in communication. In this course, students will receive an introduction to the principle, performance and applications of communication systems.
- Students will learn the various means and modes of communication. They will gain an understanding of fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- They will gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Students will be able to analyze different parameters of analog communication techniques.
- They will learn the need of sampling and different sampling techniques where they can sample analog signal.
- Students will learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- They will gain an in-depth understanding of different concepts used in a satellite communication system.
- They will study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- Students will understand evolution of mobile communication generations 2G, 3G, and 4G with their characteristics and limitations.
- This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

- Students will apply the theory that they have learned in the theory class to gain hands on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to construct TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.

Unit 1

Electronic communication: Introduction to communication – means and modes. Power measurements (units of power). Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals.

(4 Lectures)

Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Single Sideband (SSB) systems, advantages of SSB transmission, Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector),Qualitative idea of Super heterodyne receiver.

(12 Lectures)

Unit 2

Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing).

(9Lectures)

Unit 3

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying(PSK), and Binary Phase Shift Keying (BPSK).

(10 Lectures)

Unit 4

Satellite Communication: Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), Uplink and downlink, path loss, Satellite visibility, Ground and earth stations. Simplified block diagram of earth station.

(10 Lectures)

Unit 5

Mobile Telephony System: Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only), GPS navigation system (qualitative idea only).

(15 Lectures)

Practical: 60 Hours

PHYSICS LAB-DSE LAB: Communication System Lab

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to specific experiments done in the lab.

At Least 05 Experiments from the following

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

References

1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2. Advanced Electronics Communication Systems- Tomasi, 6^{th} Edn. Prentice Hall.
3. Modern Digital and Analog Communication Systems, B.P. Lathi, 4th Edition, 2011, Oxford University Press.
4. Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
5. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
6. Communication Systems, S. Haykin, 2006, Wiley India
7. Electronic Communication system, Blake, Cengage, 5th edition.
8. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press
9. Introduction to Communication systems, U. Madhow, 1st Edition, 2018, Cambridge University Press

DSE: Medical Physics (32227615)
Credit : 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical : 60 Hours

Course Objective

This course introduces a student to the basics of Medical Physics.

Course Learning Outcomes

This course will enable the student to

- Focus on the application of Physics to clinical medicine.
- Gain a broad and fundamental understanding of Physics while developing particular expertise in medical applications.
- Learn about the human body, its anatomy, physiology and BioPhysics, exploring its performance as a physical machine.
- Learn diagnostic and therapeutic applications like the ECG, Radiation Physics, X-ray technology, ultrasound and magnetic resonance imaging.
- Gain knowledge with reference to working of various diagnostic tools, medical imaging techniques
- Understand interaction of ionizing radiation with matter - its effects on living organisms and its uses as a therapeutic technique and also radiation safety practices.
- Imparts functional knowledge regarding need for radiological protection and the sources of an approximate level of radiation exposure for treatment purposes.
- In the laboratory course, the student will be exposed to the workings of various medical devices and getting familiarized with various detectors used in medical imaging, medical diagnostics. The hands-on experience will be very useful for the students from job perspective.

Unit 1

PHYSICS OF THE BODY-I: Basic Anatomical Terminology: Standard Anatomical Position, Planes. Familiarity with terms like- Superior, Inferior, Anterior, Posterior, Medial, Lateral, Proximal and Distal. Mechanics of the body: Skeleton, forces, and body stability. Muscles and dynamics of body movement. Physics of Locomotors Systems: joints and movements, Stability and Equilibrium. Energy household of the body: Energy balance in the body, Energy consumption of the body, Heat losses of the body, Thermal Regulation. Other Systems in the body: Pressure system of body. Physics of breathing, Physics of cardiovascular system.

(8 Lectures)

Unit 2

PHYSICS OF THE BODY-II: Acoustics of the body: Nature and characteristics of sound, Production of speech, Physics of the ear, Diagnostics with sound and ultrasound. Optical system of the body: Physics of the eye. Electrical system of the body: Physics of the nervous system, Electrical signals and information transfer.

(10 Lectures)

Unit 3

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-I: X-Rays: Electromagnetic spectrum, production of x-rays, x-ray spectra, Brehmsstrahlung, Characteristic x-ray. X-ray tubes & types: Coolidge tube, x-ray tube design, tube cooling stationary mode, Rotating anode x-ray tube, Tube rating, quality and intensity of x-ray. X-ray generator circuits, half wave and full wave rectification, filament circuit, kilo voltage circuit. Single and three phase electric supply. Power ratings. Types of X-Ray Generator, high frequency generator, exposure timers and switches, HT cables.

(7 Lectures)

Radiation Physics: Radiation units exposure, absorbed dose, units: rad, gray, relative biological effectiveness, effective dose- Rem & Sievert, inverse square law. Interaction of radiation with matter Compton & photoelectric effect, linear attenuation coefficient. Radiation Detectors: ionization (Thimble chamber, condenser chamber), chamber. Geiger Muller counter, Scintillation counters and Solid-State detectors, TFT.

(7 Lectures)

Unit 4

MEDICAL IMAGING PHYSICS: Evolution of Medical Imaging, X-ray diagnostics and imaging, Physics of nuclear magnetic resonance (NMR), NMR imaging, MRI Radiological imaging, Ultrasound imaging, Physics of Doppler with applications and modes, Vascular Doppler. Radiography: Filters, grids, cassette, X-ray film, film processing, fluoroscopy. Computed tomography scanner- principle and function, display, generations, mammography. Thyroid uptake system and Gamma camera (Only Principle, function and display).

(9 Lectures)

RADIATION ONCOLOGY PHYSICS: External Beam Therapy (Basic Idea): Telecobalt,Conformal Radiation Therapy (CRT), 3DCRT, IMRT, Image Guided Radiotherapy, EPID, Rapid Arc, Proton Therapy, Gamma Knife, Cyber Knife. Contact Beam Therapy (Basic Idea): Brachytherapy- LDR and HDR, Intra Operative Brachytherapy. Radiotherapy, kilo voltage machines, deep therapy machines, Telecobalt machines, Medical linear accelerator. Basics of Teletherapy units, deep X-ray, Telecobalt units, Radiation protection, external beam characteristics, dose maximum and build up – bolus, percentage depth dose, tissue maximum ratio and tissue phantom ratio, Planned target Volume and Gross Tumour Volume.

(9 Lectures)

Unit 5

RADIATION AND RADIATION PROTECTION: Principles of radiation protection, protective materials-radiation effects, somatic, genetic stochastic and deterministic effect.

Personal monitoring devices: TLD film badge, pocket dosimeter, OSL dosimeter. Radiation dosimeter. Natural radioactivity, Biological effects of radiation, Radiation monitors. Steps to reduce radiation to Patient, Staff and Public. Dose Limits for Occupational workers and Public. AERB: Existence and Purpose.

(5 Lectures)

Unit 6

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-II: Diagnostic nuclear medicine: Radiopharmaceuticals for radioisotope imaging, Radioisotope imaging equipment, Single photon and positron emission tomography. Therapeutic nuclear medicine: Interaction between radiation and matter Dose and isodose in radiation treatment. Medical Instrumentation: Basic Ideas of Endoscope and Cautery, Sleep Apnea and Cpap Machines, Ventilator and its modes.

(5 Lectures)

Practical: 60 Hours

PHYSICS LAB-DSE LAB: Medical Physics Lab

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

1. Understanding the working of a manual Hg Blood Pressure monitor, Stethoscope and to measure the Blood Pressure.
2. Understanding the working of a manual optical eye-testing machine and to learn eye-testing procedure.
3. Correction of Myopia (short sightedness) using a combination of lenses on an optical bench/breadboard.
4. Correction of Hypermetropia/Hyperopia (long sightedness) using a combination of lenses on an optical bench/breadboard.
5. To learn working of Thermoluminescent dosimeter (TLD) badges and measure the background radiation.
   (i) Familiarization with Geiger-Muller (GM) Counter & to measure background radiation
   (ii) Familiarization with Radiation meter and to measure background radiation.
   (iii) Familiarization with the Use of a Vascular Doppler.

References

1. Medical Physics, J.R. Cameron and J.G.Skofronick, Wiley (1978)
2. Basic Radiological Physics Dr. K.Thayalan- Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi (2003)
3. Christensen’s Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
4. Physics of the human body, Irving P. Herman, Springer (2007).
5. Physics of Radiation Therapy: F M Khan - Williams and Wilkins, 3 rd edition (2003)

6. The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)
7. Handbook of Physics in Diagnostic Imaging: R.S.Livingstone: B.I. Publication Pvt Ltd.
8. The Physics of Radiology-H E Johns and Cunningham.
9. Physics of Radiation Therapy : F M Khan - Williams and Wilkins, 3rd edition (2003)
10. Handbook of Physics in Diagnostic Imaging: R.S. Livingstone: B.I. Publications Pvt Ltd.

DSE: Applied Dynamics (32227616)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

Most processes encountered in nature are inherently nonlinear. This course introduces the main topics of low-dimensional nonlinear systems, with applications to a wide variety of disciplines, including physics, engineering, mathematics, chemistry, and biology. Specific topics include maps and flows in one and two dimensions, phase portraits, bifurcations, chaos, fractals and elementary fluid dynamics. Students will obtain familiarity with concepts and methods in the field of dynamical systems, apply those concepts and methods to analyze dynamic models analytically and computationally, and will learn how to interpret and critically evaluate the results of those analyses. This course begins with the first order dynamical system and the idea of phase space, flows and trajectories and ends with the elementary fluid dynamics. Students will also appreciate the introduction to chaos and fractals. The emphasis of this course is to enhance the understanding of the basics of applied dynamics. By the end of this course, students should be able solve the seen or unseen problems/numerical in applied dynamics.

Course Learning Outcomes

Upon successful course completion, a student will be able to:

- Demonstrate understanding of the concepts that underlay the study of dynamical systems. Use the analytical and computational methods covered in this course to analyze dynamical systems models.
- Understand fractals as self-similar structures by giving examples from nature and develop mathematical models for simple fractal structures.
- Understand various forms of dynamics and different routes to chaos.
- Analyze the behavior of dynamical systems (e.g. find periodic orbits and assess their stability, draw phase portraits, etc.).
- Understand basic Physics of fluids and its dynamics theoretically and experimentally and by computational simulations: Basic properties of fluids including viscosity, thermal conductivity, mass diffusivity, equation of state. Also, Physics of different types of fluid flow phenomena as well as fluid flow visualizations like streamlines, pathlines and streakline flows.

- Apply the techniques of nonlinear dynamics to physical processes drawn from a variety of scientific and engineering disciplines.
- Analyze uniform and non uniform oscillators (flows on circle)
- Draw phase portraits and interpret them in several applications from biology, physics, chemistry and engineering.
- In the Lab course, students will be able to perform Simulations/Lab experiments on: Determination of the coupling Coefficients of Coupled pendulums and other coupled Oscillators, Simulation of Simple Population Models, Experimental growth and Decay, Logistic growth, Species Competition, Predator-Prey Dynamics, Simple genetic circuits, Solve rate equations numerically for some simple chemical reactions, Simulation of Fractal Formation in Deterministic Fractals, Self Similar Fractals and Fractals in nature like Trees, Coastlines and Earthquakes, Simulation of some Fluid Flow Models like Streamlines, Pathlines, and Streakline flows

Unit 1

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems: simple and damped harmonic oscillator. Sketching flows and trajectories in phase space. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems. Examples of dynamical systems – Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics. Rate equations for chemical reactions e.g. auto catalysis, bistability.

(22 Lectures)

Unit 2

Introduction to Chaos and Fractals: Chaos in nonlinear equations - Logistic map and Lorenz equations: Dynamics from time series. Parameter dependence- steady, periodic and chaotic states. Cobweb iteration. Fixed points. Defining chaos- a periodic, bounded, deterministic and sensitive dependence on initial conditions. Period- Doubling route to chaos.

Self-similarity and fractal geometry: Fractals in nature - trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure.

(18 Lectures)

Unit 3

Elementary Fluid Dynamics: Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis-concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties-viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform and non-uniform flows, viscous and inviscid flows, incompressible and compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows. Flow visualization - streamlines, pathlines, Streaklines.

(20 Lectures)

Practical: 60 Hours

PHYSICS LAB-DSE LAB: Applied Dynamics Lab

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.
Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like (at least 06 experiments)

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
   (i) To study examples from game theory.
   (ii) To study period doubling route to chaos in logistic map.
   (iii) To study various attractors of Lorenz equations.
   (iv) Computational visualization of fractal formations of Deterministic fractal.
   (v) Computational visualization of fractal formations of self-similar fractal.
   (vi) Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.
   (vii) Computational Flow visualization - streamlines, pathlines, Streaklines.

References for Theory:

1. Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. Nonlinear Dynamics: Integrability, Chaos and Patterns, M. Lakshmanan and S. Rajasekar, Springer, 2003.
4. An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
5. Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

References for Practical:

1. Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer

DSE: Digital Signal Processing (32227621)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals.
- This paper also highlights the concept of filters and realization of Digital Filters.
- At the end of the syllabus, students will develop an understanding of Discrete and fast Fourier Transform.

Course Learning Outcomes

In this course, students will be able to develop a thorough understanding of the central elements of discrete time signal processing theory and correlate this theory with the real-world signal processing applications. At the end of this course, students will be able to develop following learning outcomes:

- Students will learn basic discrete-time signal and system types, convolution sum, impulse and frequency response concepts for linear time-invariant (LTI) systems.
- The student will be in position to understand use of different transforms and analyze the discrete time signals and systems. They will learn to analyze a digital system using z-transforms and discrete time Fourier transforms, region of convergence concepts, their properties and perform simple transform calculations,.
- The student will realize the use of LTI filters for filtering different real world signals. The concept of transfer
- Function and difference-Equation System will be introduced. Also, they will learn to solve Difference Equations.
- Students will develop an ability to analyze DSP systems like linear-phase, FIR, IIR, All-pass, averaging and notch Filter etc.
- Students will be able to understand the discrete Fourier transform (DFT) and realize its implementation using FFT techniques.
- Students will be able to learn the realization of digital filters, their structures, along with their advantages and disadvantages. They will be able to design and understand different types of digital filters such as finite & infinite impulse response filters for various applications.

- In the Lab course, the students will realize various concepts using Scilab simulations like Digital Filters and their classifications based on the response, design and algorithm, Fluency in using Fast Fourier Transform, Signal generation, realization of systems and finding their transfer function, characterization using pole-zero plots and designing digital filters.

Unit 1

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response.

(10 Lectures)

Unit 2

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; **Frequency Shifting;** Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. The z-Transform: Bilateral (Two-Sided) z-Transform, Inverse z-Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of- Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the z-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations.

(15 Lectures)

Unit 3

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters.

(5 Lectures)

Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing.

(10 Lectures)

Unit 4

Fast Fourier Transform: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (WN), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms.

(5 Lectures)

Unit 5

Realization of Digital Filters: Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; Direct-Form I. Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators. Infinite Impulse Response Digital Filter: Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method.

(15 Lectures)

Practical: 60 Hours

PRACTICAL-DSE LAB: Digital Signal Processing Lab

At least 06 experiments from the following using Scilab/Matlab. Introduction to Numerical computation software Scilab/Matlab be introduced in the lab.

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence $u(n)$, (c) ramp sequence $r(n)$, (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \le n \le 50$.

2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for N = 5

$$x(n) = rect\left(\frac{n}{2N}\right) = \Pi\left(\frac{n}{2N}\right) = \begin{cases} 1 & -N \le n \le N \\ 0 & otherwise \end{cases}$$

3. An LTI system is specified by the difference equation

$$y(n) = 0.8y(n-1) + x(n)$$

(a) Determine $H\left(e^{jw}\right)$

(b) Calculate and plot the steady state response $y_{ss}(n)$ to

$$x(n) = \cos(0.5\pi n)u(n)$$

4. Given a casual system

$$y(n) = 0.9y(n-1) + x(n)$$

(a) Find $H(z)$ and sketch its pole-zero plot

(b) Plot the frequency response $\left|H\left(e^{jw}\right)\right|$ and $\angle H\left(e^{jw}\right)$

5. Design a digital filter to eliminate the lower frequency sinusoid of $x(t) = \sin 7t + \sin 200t$. The sampling frequency is $f_s = 500\ Hz$. Plot its pole zero diagram, magnitude response, input and output of the filter.

6. Let $x(n)$ be a 4-point sequence:

$$x(n) = \underset{\uparrow}{\{1,1,1,1\}} = \begin{cases} 1 & 0 \le n \le 3 \\ 0 & otherwise \end{cases}$$

Compute the DTFT $X\left(e^{jw}\right)$ and plot its magnitude

(a) Compute and plot the 4 point DFT of $x(n)$

(b) Compute and plot the 8 point DFT of $x(n)$ (by appending 4 zeros)

(c) Compute and plot the 16 point DFT of $x(n)$ (by appending 12 zeros)

7. Let $x(n)$ and $h(n)$ be the two 4-point sequences,

$$x(n) = \{1, \underset{\uparrow}{2}, 2, 1\}$$

$$h(n) = \{1, -\underset{\uparrow}{1}, -1, 1\}$$

Write a program to compute their linear convolution using circular convolution.

8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

9. Design an FIR filter to meet the following specifications:

passband edge $F_p = 2\,KHz$

stopband edge $F_s = 5\,KHz$

Passband attenuation $A_p = 2\,dB$

Stopband attenuation $A_s = 42\,dB$

Sampling frequency $F_s = 20\,KHz$

10. The frequency response of a linear phase digital differentiator is given by

$$H_d\left(e^{jw}\right) = jwe^{-j\tau w} |w| \le \pi$$

Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response.

References:

1. Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press, India.
2. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
3. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
4. Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.
5. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
6. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.

DSE: Physics of Earth (32227624)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

This course familiarizes the students with the origin of universe and role of earth in the solar system.

Course Learning Outcomes

- At the end of this course student will be able to
- Have an overview of structure of the earth as well as various dynamical processes occurring on it.
- Develop an understanding of evolution of the earth.
- Apply physical principles of elasticity and elastic wave propagation to understand modern global seismology as a probe of the Earth's internal structure.
- Understand the origin of magnetic field, Geodynamics of earthquakes and the description of seismic sources; a simple but fundamental theory of thermal convection; the distinctive rheological behaviour of the upper mantle and its top.
- Explore various roles played by water cycle, carbon cycle, nitrogen cycles in maintaining steady state of earth leading to better understanding of the contemporary dilemmas (climate change, bio diversity loss, population growth, etc.) disturbing the Earth
- In the tutorial section, through literature survey on the various aspects of health of Earth, project work / seminar presentation, the students will be able to appreciate need to 'save' Earth.

Unit 1

The Earth and the Universe:

(a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography . Introduction to various branches of Earth Sciences.

(b) General characteristics and origin of the Universe. The Big Bang Theory. Age of the universe and Hubble constant. Formation of Galaxies. The Milky Way galaxy, Nebular Theory, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Titius-Bode law. Asteroid belt. Asteroids: origin types and examples. Meteorites & Asteroids. Earth in the Solar system ,origin, size, shape, mass, density, rotational and revolution parameters and its age.

(c) Energy and particle fluxes incident on the Earth. (d) The Cosmic Microwave Background.

(17 Lectures)

Unit 2

Structure:

(a) The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior?
(b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.
(c) The Atmosphere: layers, variation of temperature with altitude, adiabatic lapse rate, variation of density and pressure with altitude, cloud formation.
(d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers, permafrost.

(18 Lectures)

Unit 3

Dynamical Processes:

(a) The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; types of plate movements, hotspots; sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Seismic waves, Richter scale, geophones. Volcanoes: types products and distribution.
(b) The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, tend – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.
(c) The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones and anti-cyclones.
Climate: i. Earth's temperature and greenhouse effect. ii. Paleoclimate and recent climate changes. iii. The Indian monsoon system.
(d) Biosphere: Water cycle, Carbon cycle. The role of cycles in maintaining a steady state.

(18 Lectures)

Unit 4

Evolution:

Stratigraphy: Introduction and types, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Time line of major geological and biological events. Introduction to geochronological methods and their application in geological studies. Radiometric dating: Advantages & disadvantages of various isotopes. History of development of concepts of uniformitarianism, catastrophism and neptunism. Various laws of stratigraphy. Introduction to the geology and geomorphology of Indian subcontinent. Origin of life on Earth, Role of the biosphere in shaping the environment. Future of evolution of the, Earth and solar system: Death of the Earth (Probable causes).

(18 Lectures)

Unit 5

Disturbing the Earth – Contemporary dilemmas (a) Human population growth. (b) Atmosphere: Green house gas emissions, climate change, air pollution. (c) Hydrosphere: Fresh water depletion. (d) Geosphere: Chemical effluents, nuclear waste. (e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

(4 Lectures)

References

1. Planetary Surface Processes, H. Jay Melosh, 2011, Cambridge University Press.
2. Consider a Spherical Cow: A course in environmental problem solving, John Harte, University Science Books
3. Holme's Principles of Physical Geology, 1992, Chapman & Hall.
4. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment, C. Emiliani, 1992, Cambridge University Press.
5. The Blue Planet: An Introduction to Earth System Science, Brian J. Skinner, Stephen C. Portere, 1994, John Wiley & Sons.
6. Physics of the Earth, Frank D. Stacey, Paul M. Davis, 2008, Cambridge University Press.
7. Fundamentals of Geophysics, William Lowrie, 1997, Cambridge University Press.
8. The Solid Earth: An Introduction to Global Geophysics, C. M. R. Fowler, 1990, Cambridge University Press.
9. The Earth: A Very Short Introduction, Martin Redfern, 2003, Oxford University Press.
10. Galaxies: A Very Short Introduction, John Gribbin, 2008, Oxford University Press.
11. Climate Change: A Very Short Introduction, Mark Maslin, 3 rd Edition, 2014, Oxford University Press.
12. The Atmosphere: A Very Short Introduction, Paul I. Palmer, 2017, Oxford University Press.
13. IGNOU Study material: PHE 15 Astronomy and Astrophysics Block 2

DSE: Advanced Mathematical Physics-II (32227625)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

The course is intended to develop new mathematical tools in terms of Calculus of Variation, Group Theory and Theory of Probability in the repertoire of the students to apply in Theoretical and Experimental Physics.

Course Learning Outcomes

After the successful completion of the course, the students shall be able to

- Understand variational principle and apply it to calculate: (i) Geodesics in two and three dimensions (ii) Euler Lagrange Equation and apply it simple problems in one and two dimensions.
- Acquire basic concept of Hamiltonian, Hamilton's principle and Hamiltonian equation of motion, Poisson and Lagrange brackets.
- Learn elementary group theory, i.e., definition and properties of groups, subgroups, Homomorphism, isomorphism, normal and conjugate groups, representation of groups, Reducible and Irreducible groups.
- Learn the theory of probability, Random variables and probability distributions, Expectation values and variance. Various examples of probability distributions used in physics. The principle of least squares.

Unit 1

Variable Calculus: Variational Principle, Euler's Equation and its Application to Simple Problems. Geodesics. Calculus of Variations. Concept of Lagrangian: Generalized co-ordinates. Definition of canonical moment, Euler-Lagrange's Equations of Motion and its Applications to Simple Problems (e.g., Simple Pendulum and One dimensional harmonic oscillator). Definition of Canonical Momenta. Canonical Pair of Variables. Definition of Generalized Force: Definition of Hamiltonian (Legendre Transformation). Hamilton's Principle. Poisson Brackets and their properties. Lagrange Brackets and their properties.

(25 Lectures)

Unit 2

Group Theory: Review of sets, Mapping and Binary Operations, Relation, Types of Relations. Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel. Some special groups : SO(2), SO(3), SU(2), SU(3).

(25 Lectures)

Unit 3

Advanced Probability Theory: Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability distributions, Expectation and Variance, Special Probability distributions: The binomial distribution, The poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares.

(25 Lectures)

References

1. Mathematical Methods for Physicists: Weber and Arfken, 2005, Academic Press.
2. Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.
3. Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley.
4. Group Theory and its Applications to Physical Problems by Morton Hamermesh, 1989, Dover
5. Introduction to Mathematical Physics: Methods & Concepts: Chun Wa Wong, 2012, Oxford University Press
6. Introduction to Mathematical Probability, J. V. Uspensky, 1937, Mc Graw-Hill.

DSE: Classical Dynamics (32227626)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

This course on classical dynamics trains the student in problem solving ability and develops understanding of physical problems. The course begins with the review of Newton's Laws of Motion and ends with the Special The of Relativity by 4-vector approach and fluids. Students will also learn the Lagrangian and Hamiltonian Mechanics. The emphasis of this course is to enhance the understanding of Classical Mechanics (Lagrangian and Hamiltonian Approach). By the end of this course, students should be able to solve the seen or unseen problems/numericals in classical mechanics.

Course Learning Outcomes

At the end of this course, students will be able to:

- Understand the physical principle behind the derivation of Lagrange and Hamilton equations, and the advantages of these formulations.
- Translate physical problems into appropriate mathematical language and apply appropriate mathematical tools – particularly, calculus, differential equations, linear algebra, and the calculus of variations – to analyze and solve the resulting equations.
- Apply Lagrangian & Hamiltonian methods to complex motion problems.
- One will be able to relate symmetries to conservation laws in physical systems, and apply these concepts to practical situations.
- Understand the intricacies of motion of particle in central force field. Critical thinking and problem-solving skills
- Review the retarded potentials, potentials due to a moving charge, Lienard Wiechert potentials, electric and magnetic fields due to a moving charge, power radiated, Larmor's formula and its relativistic generalization.
- Recapitulate and learn the special theory of relativity- postulates of the special theory of relativity, Lorentz transformations on space-time and other four vectors, four-vector notations, space-time invariant, length contraction, time dilation, mass-energy relation, Doppler effect, light cone and its significance, problems involving energy- momentum conservations.
- Learn the basics of fluid dynamics, streamline and turbulent flow, Reynolds's number, coefficient of viscosity and Poiseuille's equation.
- Upon taking the classical dynamics course students will be able to integrate competently the knowledge and skills acquired in post-undergraduate studies.

Unit 1

Classical Mechanics of Point Particles: Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyro-frequency, motion in crossed electric and magnetic fields. Degrees of freedom of a system, Generalized coordinates and velocities. Hamilton's Principle, Lagrangian and Lagrange's equations of motion of one- dimensional simple harmonic oscillators, falling body in uniform gravity. Cyclic coordinates. Canonical momenta & Hamiltonian. Hamilton's equations of motion. Comparison of Newtonian, Lagrangian and Hamiltonian mechanics. Applications of Hamiltonian mechanics: Hamiltonian for a simple harmonic oscillator, solution of Hamilton's equations for simple harmonic oscillations (1-D), particle in a Central Force Field – conservation of angular momentum and energy.

(25 Lectures)

Unit 2

Small Amplitude Oscillations: Minima of potential energy and points of stable equilibrium, small amplitude oscillations about the minimum, normal modes of longitudinal simple harmonic oscillations (maximum 3 masses connected by 4 springs). Kinetic energy

(T) and potential energy (V) in terms of normal co-ordinates. T and V matrices: finding eigen-frequencies and eigen-vectors using these matrices.

(15 Lectures)

Unit 3

Special Theory of Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams: Time-dilation, Length contraction, Simultaneity.

Four -vectors: space-like, time-like and light-like. Four-displacement four velocity, four-acceleration four-space. Four-momentum and energy-momentum relation. Doppler effect from a 4-vector perspective. Application to two-body decay of an unstable particle. Metric tensor and alternating tensors and their properties.

(25 Lectures)

Unit 4

Fluid Dynamics: Density ρ and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe. Analogy between liquid flow and current flow, rate of liquid flow through capillaries in series and in parallel combination. Navier Stoke's equation, Reynolds number.

(10 Lectures)

References

1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rdEdn. 2002,Pearson Education. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
2. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
3. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
4. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press
5. Classical Mechanics, Tai L. Chow, CRC Press.
6. An Introduction to Fluid Dynamics, G. K. Batchelor, Cambridge University Press, 2002.

DSE: Dissertation (32227627)
Credit:06

Course Objective

Dissertation involves project work with the intention of exposing the student to research /development. It involves open ended learning based on student ability and initiative, exposure to scientific writing and inculcation of ethical practices in research and communication.

Course Learning Outcomes

- Exposure to research methodology
- Picking up skills relevant to dissertation project, such as experimental skills in the subject, computational skills, etc.
- Development of creative ability and intellectual initiative
- Developing the ability for scientific writing
- Becoming conversant with ethical practices in acknowledging other sources, avoiding plagiarism, etc.

Guidelines for dissertation:

1. The dissertation work should not be a routine experiment or project at the under graduate level. It should involve more than text book knowledge. Referring text books for preparation and understanding concepts is allowed; however one component of the dissertation must include study of research papers or equivalent research material and/or open ended project.
2. The total number of dissertations allowed should be limited to 5% of the total strength of the students in the programme. However, students having national scholarships like NTSE, KVPY, INSPIRE, etc. can be considered above this quota. The selection criterion is at the discretion of the college. The student should not have any academic backlog (Essential Repeat). The sole/single supervisor must have a Ph.D. degree. Not more than two candidates would be enrolled under same supervisor.
3. At the time of submission of teaching work-load of the teachers by the college to the Department (Department of Physics and Astrophysics, Delhi University), the supervisor shall submit the proposal (200-300 words; not more than one full A4 page) of the proposed dissertation. Along with that four names of the external examiners from any college of Delhi University (other than the own college of the supervisor) or any department of Delhi University can be suggested. The committee of courses of the department may appoint any one teacher as an external examiner from the proposed list of external examiners.

4. No topic would be repeated from the topics allotted by the supervisor in the previous years, so that the work or dissertation could be distinct every time. The 'proposal' should include the topic, plan of work, and clearly state the expected deliverables. The topic must be well defined. The abstract should clearly explain the significance of the suggested problem. It must emphasize the specific skills which the student shall be learning during the course of dissertation, for example, some computational skill or literature survey, etc. Both internal (supervisor) and external examiners will assess the student at the end of the semester and award marks jointly, according to the attached scheme.
5. Other than the time for pursuing dissertation work, there must be at least 2 hours of interaction per week, of the student with the supervisor. The student has to maintain a "Log Book" to summarize his/ her weekly progress which shall be duly signed by the supervisor. Experimental work should be carried out in the parent college or any other college or the Department in Delhi University with the consent of a faculty member there. Unsupervised work carried out at research institutions / laboratories is to be discouraged.
6. The dissertation report should be of around 30 pages. It must have minimum three chapters namely (1) Introduction, (2) the main work including derivations / experimentation and Results, and (3) Discussion and Conclusion. At the end, adequate references must be included. Plagiarism should be avoided by the student and this should be checked by the supervisor.
7. It is left to the discretion of the college if it can allow relaxation of two teaching periods (at the most two periods per week to the supervisor, irrespective of the number of students enrolled under him / her for dissertation). The evaluation/presentation of the dissertation must be done within two weeks after the exams are over. For the interest of the students it is advised that college may organize a workshop for creating awareness amongst students. Any teacher who is not Ph.D. holder can be Co-supervisor with the main supervisor.

Assessment of dissertation

MARKING SCHEME for Dissertation:

- 30 marks: Internal assessment based on performance like sincerity, regularity, etc. Awarded by: Supervisor
- 40 marks: Written Report (including content and quality of work done). Awarded by: Supervisor and External Examiner.
- 30 marks: Presentation*. Awarded by: Supervisor and External Examiner.

*All Dissertation presentations should be open. Other students / faculty should be encouraged to attend.

DSE: Verilog and FPGA based system design (32227628)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This paper provides a review of combinational and sequential circuits such as multiplexers, demultiplexers, decoders, encoders and adder circuits.
- Evolution of Programmable logic devices such as PAL, PLA and GAL is explained.
- At the end of the syllabus, students will be able to understand the modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design.

Course Learning Outcomes

This paper discusses the fundamental Verilog concepts in-lieu of today's most advanced digital design techniques. At the end of this course, students will be able to develop following learning outcomes:

- Understand the steps and processes for design of logic circuits and systems.
- Be able to differentiate between combinational and sequential circuits.
- Be able to design various types of state machines.
- Be able to partition a complex logic system into elements of data-path and control path.
- Understand various types of programmable logic building blocks such as CPLDs and FPGAs and their tradeoffs.
- Be able to write synthesizable Verilog code.
- Be able to write a Verilog test bench to test various Verilog code modules.
- Be able to design, program and test logic systems on a programmable logic device (CPLD or FPGA) using Verilog.

Unit 1

Digital logic design flow. Review of combinational circuits. Combinational building blocks: multiplexors, demultiplexers, decoders, encoders and adder circuits. Review of sequential circuit elements: flip-flop, latch and register. Finite state machines: Mealy and Moore. Other sequential circuits: shift registers and counters. FSMD (Finite State Machine with Datapath): design and analysis. Microprogrammed control. Memory basics and timing. Programmable Logic devices.

(20 lectures)

Unit 2

Evolution of Programmable logic devices. PAL, PLA and GAL. CPLD and FPGA architectures. Placement and routing. Logic cell structure, Programmable interconnects, Logic blocks and I/O Ports. Clock distribution in FPGA. Timing issues in FPGA design. Boundary scan.

(20 lectures)

Unit 3

Verilog HDL: Introduction to HDL. Verilog primitive operators and structural Verilog Behavioral Verilog. Design verification. Modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design examples in Verilog.

(20 lectures)

Practical : 60 Hours

PRACTICALS-DSE LAB: Verilog and FPGA based system design Lab

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to specific experiments done in the lab.

At least 06 Experiments from the following

1. Write code to realize basic and derived logic gates.
2. Half adder, Full Adder using basic and derived gates.
3. Half subtractor and Full Subtractor using basic and derived gates.
4. Design and simulation of a 4 bit Adder.
5. Multiplexer (4x1) and Demultiplexer using logic gates.
6. Decoder and Encoder using logic gates.
7. Clocked D, JK and T Flip flops (with Reset inputs)
8. 3-bit Ripple counter
9. To design and study switching circuits (LED blink shift)
10. To design traffic light controller.
11. To interface a keyboard
12. To interface a LCD using FPGA
13. To interface multiplexed seven segment display.
14. To interface a stepper motor and DC motor.
15. To interface ADC 0804.

References

1. Lizy Kurien and Charles Roth. Principles of Digital Systems Design and VHDL. Cengage Publishing. ISBN-13:978-8131505748
2. Palnitkar, Samir, Verilog HDL. Pearson Education; Second edition (2003).
3. Ming-Bo Lin. Digital System Designs and Practices: Using Verilog HDL and FPGAs. Wiley India Pvt Ltd. ISBN-13: 978-8126536948
4. Zainalabedin Navabi. Verilog Digital System Design. TMH; 2nd edition. ISBN-13: 978-0070252219

5. Wayne Wolf. FPGA Based System Design. Pearson Education. S. K. Mitra, Digital Signal processing, McGraw Hill, 1998
6. VLSI design, Deba prasad Das, 2nd Edition, 2015, Oxford University Press.
7. D.J. Laja and S. Sapatnekar, Designing Digital Computer Systems with Verilog, Cambridge University Press, 2015.
8. U. Meyer Baese, Digital Signal Processing with FPGAs, Springer, 2004
9. Verilog HDL primer- J. Bhasker. BSP, 2003 II edition

DSE: Advanced Quantum Mechanics (xxx4)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

This course aims to describe quantum phenomena in terms of linear vector space formalism. The students will be able to learn to represent quantum states by ket vectors and physical observables as operators and their time evolution. Commutation relations between observables will be studied since it is fundamental to understanding uncertainty principle as well as deriving the eigen values of angular momenta. The complete set of commuting observables will be introduced. An understanding of identical particles like bosons and fermions will be developed. At the end of the syllabus, students will be able to learn angular momenta algebra and the computation of Clebsch-Gordan coefficients.

Course Learning Outcomes

This course will aim the B.Sc.(Hons.) physics students with modern analytical techniques so that they can easily apply them to research areas involving lasers interacting with atoms/molecules, manipulate entangled quantum states like qubits, so necessary in the field of quantum information theory and quantum computation, deal effectively with superconductors and superfluidity, etc.

- The world is marching towards attainment of quantum computers, which in turn is likely to revolutionize the field of Artificial Intelligence (AI).
- After learning this course properly, our students would be adequately prepared to participate and innovate in the coming AI revolution.
- As this course starts with an introduction to linear vector spaces and inner product of two vectors that results in a complex number, aided by problem solving exercises, students will imbibe a critical understanding of the general mathematical structures of complex analysis, vector spaces, basis and orthogonality, which form the underlying principles of diverse topics like Fourier transform, matrices and their diagonalisation, Laurent series and calculus of residues, etc. which in turn constitute the bedrock of signal processing, Wiener-Khinchin theorem, Match filtering, etc. that are extremely useful in communication, radar techniques, detection of weak signals, gravitational wave data analysis, operation research, etc.
- Intense problem-solving sessions will enable the students to develop analytical and mathematical imagination that are necessary to be creative in physical sciences as well as engineering research areas.

- The quantum dynamics of two-level systems will help the students to understand the principles of NMR, ESR and MRI. Such systems are also very useful as far as comprehension and implementation of qubit structures that are of paramount importance to future quantum computers.

Unit 1

Motivation for developing a linear vector space formulation to describe quantum phenomena.
Brief review of linear vector spaces with ket notation: Inner product, norm, Schwarz inequality, linear operators, eigenvalue and eigenvector, adjoint of a linear operator, Hermitian or self-adjoint operators and their properties. Orthonormal basis – discrete and continuous. Unitary operators and change of basis. Completeness, closure relation. The position and momentum representations, Relation between wave functions and kets, given an orthonormal basis. Bra vectors.

(17 lectures)

Unit 2

Representation of quantum states by ket vectors and physical observables by Hermitian operators. Unitary time-evolution and Schrodinger equation in ket notation. Measurement of an observable. Expectation value of an observable. Canonical commutation relations - commutators of position and momentum, commutators for orbital and spin angular momentum.

(14 lectures)

Unit 3

Compatible and incompatible observables: Commutator brackets and their properties, the uncertainty principle. Ehrenfest's theorem and the classical limit. Correspondence of unitary evolution of ket vectors with Schrodinger wave mechanics.

(6 lectures)

Unit 4

Identical particles: direct product of kets, symmetric and antisymmetric states. Systems of identical non-interacting particles. Bosons and Fermions; Pauli's exclusion principle.
Dynamics of two-level systems (e.g. electron in an external magnetic field). Entangled states, Qubits; One dimensional Harmonic oscillator, its energy eigen values and eigen states using ladder operators.

(15 lectures)

Unit 5

Addition of orbital and spin angular momenta, J = L+S. Commutators of J_x , J_y and J_z ; Ladder operators, recursion relations, eigenvalues and eigenstates of total angular momentum operators. Composite system of two spin-half particles – singlet and triplet states. Clebsch-Gordan coefficients: formalism, computation (up to $l \oplus 1/2$)

(13 lectures)

Unit 6

Variational Method: Basic idea, application to some simple systems like rigid box problem and one dimensional simple harmonic oscillator; Estimation of Hydrogen atom ground state energy using variational method. Helium atom ground state energy.

(10 lectures)

References

1. Modern Quantum Mechanics, J.J Sakurai, Revised Edition, 1994, Addision-Wesley.
2. The Principles of Quantum Mechanics, P. A. M. Dirac, Clarendon Press, 2004
3. Introduction to Quantum Mechanics, David J. Griffiths, Second Edition, 2006, Pearson Education.
4. Quantum Mechanic Concepts and Applications, Nouredine Zettili, Second Edition,2001, John Wiley & Sons, Ltd.
5. A Text book of Quantum Mechanics, P.M.Mathews& K.Venkatesan, 2nd Ed., 2010, McGraw Hill.
6. Quantum Mechanics, Brian H. Bransden and C. Charles Jean Joachain, 2000, Prentice Hall.

Additional Resources:

1. Introduction to Quantum Mechanics, Volume-I, C. Cohen-Tannoudgi, B. Diu, F. Laloe, 1977, Wiley-VCH. Quantum Theory, David Bohm, Dover Publications, 1979.
2. QUANTUM MECHANICS: Theory and Applications, (2019), (Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi.
3. Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019
4. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications, 1966
5. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
6. Quantum Mechanics, Eugene Merzbacher, 2004, John Wiley and Sons, Inc.

9.3. Skill-Enhancement Elective Course - (SEC)

SEC: Physics Workshop Skills (32223901)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical : 60 Hours

Course Objective

The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode. This course enable students to understand working of various measuring devices and different type of errors student can encounter in the measurement process. This course also develop the mechanical skills of the students by direct exposure to different machines and tools by demonstration and experimental technique.

Teacher may give long duration project based on this paper.

Course Learning Outcomes

After completing this course, student will be able to :

- Learning measuring devices like Vernier callipers, Screw gauge, travelling microscope and Sextant for measuring various length scales.
- Acquire skills in the usage of multimeters, soldering iron, oscilloscopes, power supplies and relays.
- Developing mechanical skill such as casting, foundry, machining, forming and welding and will become familiar with common machine tools like lathe, shaper, drilling, milling, surface machines and Cutting tools.
- Getting acquaintance with prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axle. Lever mechanism. Lifting of heavy weight using lever. braking systems, pulleys.

Unit 1

Introduction: Measuring devices: Vernier calliper, Screw gauge and travelling microscope. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.

(6 lectures)

Unit 2

Mechanical Skill: Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet.

(14 Lectures)

Unit 3

Introduction to prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment.

(10 Lectures)

Practical: 60 Hours

PRACTICALS-SEC LAB: Physics Workshop Skills Lab

Sessions on the use of equipment used in the workshop, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

Main emphasis is on taking observations, calculations, graph and result. Perform at least three practicals from the following.

1.Comparison of diameter of a thin wire using screw gauge and travelling microscope.
2. Drilling of Hole in metal, wood and plastic.
3. Cutting of metal sheet.
4. Cutting of glass sheet
5. Lifting of heavy weights using simple pulley/lever arrangement.

References

1. A text book in Electrical Technology - B L Theraja – S. Chand and Company.
2. Performance and design of AC machines – M.G. Say, ELBS Edn.
3. Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
4. Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732] New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN0861674480].

SEC: Computational Physics Skills (32223902)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical : 60 Hours

Course Objectives

This course is intended to give an insight to computer hardware and computer applications. Students will familiarize with use of computer to solve physics problems. They will learn

- a programming language namely fortran.
- will also learn to visualize at data graphically using gnu plot.
- further will learn to prepare long formatted document using latex.

Teacher may give long duration project based on this paper.

Course Learning Outcomes

- Learn the importance of computers in solving problems in Physics.
- Learn to write the algorithm for solving a problem by drawing the flowchart of simple problems like roots of quadratic equations etc.
- Have a working knowledge about the Linux system: the necessary commands.
- Learn to write and execute FORTRAN programs in the Linux system. They should attempt the simple numerical exercises: product of matrices, sum of finite series and area under a curve, plotting trajectory of a projectile, find roots of a quadratic equation, numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization etc.
- Learn to use GUI windows, Linux commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
- The students should also learn “Scientific Word Processing”, particularly, how to use the LaTeX software in writing articles and papers which include mathematical equations and diagrams.
- The students should learn the basics of Gnuplot. He should be able to create an input Gnuplot file for plotting a data and saving the output for seeing on the screen, saving it as an eps file and as a pdf file etc.

Unit 1

Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor.

Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

(4 Lectures)

Scientific Programming: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

(5 Lectures)

Unit 2

Control Statements: Types of Logic(Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO- CONTINUE, DO-ENDDO, DO-WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems Programming:

1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at x=1

(6 Lectures)

Unit 3

Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

(6 Lectures)

Unit 4

Visualization: Introduction to graphical analysis and its limitations. Introduction to Gnuplot.importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

Practicals/Hands on exercises:

PRACTICALS-SEC LAB: Computational Physics Skills Lab

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

(9 Lectures)

References

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. Computer Programming in Fortran 77". V. Rajaraman (Publisher:PHI).
3. LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley, 1994).
4. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010).
5. Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.
6. Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi(1999).
7. Elementary Numerical Analysis, K.E.Atkinson,3rd Edn., 2007, Wiley India Edition.

SEC: Electrical circuits and Network Skills (32223903)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical : 60 Hours

Course Objectives:

This is a course to expose basic circuit concepts, circuit modeling and methods of circuit analysis in time domain and frequency domain for solving simple and multi dimensional circuits including DC and AC circuit theory and network theorems.

Teacher may give long duration project based on this paper.

Course Leaning Outcomes:

At the end of this course, students will be able to achieve the following learning outcomes:

- They would be able to demonstrate good comprehension of basic principles of electricity including ideas about voltage, current and resistance.
- They would also be proficient in identifying different combinations of circuit elements besides having sound knowledge about varying types of voltage & current - alternating and direct.
- Their familiarization with basic tenets of electrical circuits like measurement of resistance, current and voltages in different circuits would be complete.
- They would be able to analyse complicated AC and DC electrical circuits.
- They would have the ability to calculate real, imaginary and complex power components of AC sources.
- They would become proficient in power factor calculation and hence would be able to design circuits exhibiting enhanced efficiency.
- The students would develop the capacity to analyse and evaluate schematics of electrical circuits including those of power and control while demonstrating insight into tracking of interconnections within elements while identifying current flow and voltage drop.
- The students would gain knowledge about generators, transformers as also electric motors including single and three phase AC and DC. The knowledge would be inclusive to interfacing aspects besides consumer defined control of speed and power.

- The students would acquire capacity to work theoretically and practically with solid-state devices including resistors, inductors and capacitors as also diodes and rectifiers in series or shunt configurations.
- The students would also be able to delve into practical aspects related to electrical wiring like varying types of conductors and cables. basics of wiring-Star and delta connections, voltage drop and losses.

Post extensive hands-on training (laboratory exercises) the students would be able to achieve the following learning outcomes:

- They would acquire ability to measure current, voltage, power in DC and AC circuits.
- They would assimilate proficiency in fabrication of regulated power supply besides preparation of extension board
- They would be enabled to choose relevant diodes (signal or power) and design rectifiers.
- They would develop capacity to identify and suggest types and sizes of solid & stranded cables, conduit lengths, cable trays. Splices, crimps, terminal blocks and solder

Unit 1

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.

(3 Lectures)

Electrical Circuits: Basic electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

(4 Lectures)

Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

(4 Lectures)

Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

(2 Lectures)

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed & power of ac motor.

(3 Lectures)

Unit 2

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources.

(3 Lectures)

Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Relay protection device.

(3 Lectures)

Electrical Wiring: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, and solder. Preparation of extension board.

(5 Lectures)

Network Theorems:(1) Thevenin theorem (2) Norton theorem (3) Superposition theorem (4) Maximum Power Transfer theorem.

(3 Lectures)

Practical : 60 Hours

PRACTICALS-SEC LAB: Electrical circuits and Network Skills Lab

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

At least 08 Experiments from the following

1. Series and Parallel combinations: Verification of Kirchoff's law.
2. To verify network theorems: (I) Thevenin (II) Norton (III) Superposition theorem (IV) Maximum power transfer theorem
3. To study frequency response curve of a Series LCR circuit.
4. To verify (1) Faraday's law and (2) Lenz's law.
5. Programming with Pspice/NG spice.
6. Demonstration of AC and DC generator.
7. Speed of motor
8. To study the characteristics of a diode.
9. To study rectifiers (I) Half wave (II) Full wave rectifier (III) Bridge rectifier
10. Power supply (I) C-filter, (II) π- filter
11. Transformer – Step up and Step down
12. Preparation of extension board with MCB/fuse, switch, socket-plug, Indicator.
13. Fabrication of Regulated power supply.

It is further suggested that students may be motivated to pursue semester long dissertation wherein he/she may do a hands-on extensive project based on the extension of the practicals enumerated above.

References

1. Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
2. A text book in Electrical Technology - B L Theraja - S Chand & Co.
3. A text book of Electrical Technology - A K Theraja
4. Performance and design of AC machines - M G Say ELBS Edn.
5. Electrical Circuit Analysis, K. Mahadevan and C. Chitran, 2nd Edition, 2018, PHI learning Pvt. Ltd.

SEC: Basic Instrumentation Skills (32223904)
Credit:04 (Theory-02, Practical-02)
Theory : 30 Hours
Practical : 60 Hours

Course Objective

- This course is to get exposure with various aspects of instruments and their usage through hands-on mode.
- Students will obtain a thorough understanding of basics of measurement, measurement devices such as electronic voltmeter, Oscilloscope, signal and pulse generators, Impedance bridges, digital instruments etc.

Teacher may give long duration project based on this paper.

Course Learning Outcomes

At the end of this course, students will be able to develop following learning outcomes:

- The student is expected to have the necessary working knowledge on accuracy, precision, resolution, range and errors/uncertainty in measurements.
- Course learning begins with the basic understanding of the measurement and errors in measurement. It then familiarizes about each and every specification of a multimeter, multimeters, multivibrators, rectifiers, amplifiers, oscillators and high voltage probes and their significance with hands on mode.
- Explanation of the Specifications of CRO and their significance. Complete explanation of CRT.
- Students learn the use of CRO for the measurement of voltage (dc and ac), frequency and time period. Covers the Digital storage Oscilloscope and its principle of working.
- Students learn principles of voltage measurement. Students should be able to understand the advantages of electronic voltmeter over conventional multimeter in terms of sensitivity etc. Types of AC millivoltmeter should be covered.
- Covers the explanation and specifications of Signal and pulse Generators: low frequency signal generator and pulse generator. Students should be familiarized with testing and specifications.
- Students learn about the working principles and specifications of basic LCR bridge.
- Hands-on mode Understanding and usage of analog & digital instruments.

- Hands-on mode for working of digital multimeter and frequency counter.

Unit 1

Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

(4 Lectures)

Electronic Voltmeter: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only).Specifications of an electronic Voltmeter/ Multimeter and their significance.AC millivoltmeter: Type of AC millivoltmeters. Block diagram ac millivoltmeter, specifications and their significance.

(4 Lectures)

Unit 2

Oscilloscope: Block diagram of basic CRO. CRT, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence. Time base operation, synchronization.Front panel controls. Specifications of CRO and their significance.

(6 Lectures)

Use of CRO: for the measurement of voltage (dc and ac), frequency and time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: principle of working.

(3 Lectures)

Unit 3

Signal and pulse Generators: Block diagram, explanation and specifications of low frequency signal generator and pulse generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.

(4 Lectures)

Impedance Bridges: Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram and working principles of a Q- Meter. Digital LCR bridges.

(3 Lectures)

Unit 4

Digital Instruments: Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter.

(3 Lectures)

Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution.

(3 Lectures)

Practical : 60 Hours

PRACTICALS-SEC LAB: Basic Instrumentation Skills Lab

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to specific experiments done in the lab.

The test of lab skills will be of the following test items:

1. Use of an oscilloscope.
2. Oscilloscope as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Practicals:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase using Oscilloscope.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a Oscilloscope.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R,L and C using a LCR bridge/ universal bridge.

Open Ended Experiments:

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter).

It is further suggested that students may be motivated to pursue semester long dissertation wherein he/she may do a hands-on extensive project based on the extension of the practicals enumerated above.

References

1. A text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Performance and design of AC machines - M G Say ELBS Edn.

3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Logic circuit design, Shimon P. Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

SEC: Renewable Energy and Energy harvesting (32223905)
Credit:04 (Theory-02, Practical-02)
Theory : 30 Hours
Practical : 60 Hours

Course Objective

Energy drives life, movements and changes. Human beings have been dependent on fossil fuels to extract energy for a long time. But in today's world, availability of fossil fuels is increasingly becoming scarcer, and hence, one needs to plan for the distant future and for the generations yet to come and live in a decent manner. Therefore, one needs to look into and study various alternate energy sources. The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible. Similarly, water, a vital ingredient for the survival of all species, is no longer abundant. One needs to think seriously about rain water harvesting. This paper describes the ways of harvesting energy using wind, solar, mechanical, ocean, geothermal energy and so on. This paper provides a review and working of various energy harvesting systems which are installed worldwide.

Teacher may give long duration project based on this paper.

Course Learning Outcomes

- Significance of renewable energy and details concerning various sources of energy will be imparted to the students. The students are expected to learn not only the theories of the renewable sources of energy, but also to have hands-on experiences on them wherever possible.

- Some of the renewable sources of energy which should be studied here are: (i) off-shore wind energy, (ii) tidal energy, (iii) solar energy, (iv) biogas energy and (v) hydroelectricity.

- Knowledge of various sources of energy for harvesting will be given
- Understand the need of energy conversion and the various methods of energy storage
- Students will have a good understanding of various renewable energy systems, and its components.

- They will be able to gain knowledge about renewable energy technologies, different storage technologies, distribution grid, smart grid including sensors, regulation and their control.
- Student will understand the concept of direct energy conversion systems and their applications.
- Students will able to identify and design the model for sending the wind energy or solar energy plant.
- The students should observe practical demonstrations of (i) training modules of solar energy, wind energy etc., (ii) Conversion of vibration into voltage using piezoelectric materials, (iv) conversion of thermal energy into voltage using thermoelectric modules.

Unit 1

Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, bio-gas generation, geothermal energy tidal energy, Hydroelectricity.

(3 Lectures)

Unit 2

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non--convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photo-voltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

(6 Lectures)

Unit 3

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

(3 Lectures)

Unit 4

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.

Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

Geothermal Energy: Geothermal Resources, Geothermal Technologies.

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. Rain water harvesting.

(9 Lectures)

Unit 5

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezo-electricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power

Electromagnetic Energy Harvesting: Linear generators, physical/mathematical models, recent applications Carbon captured technologies, cell, batteries, power consumption Environmental issues and Renewable sources of energy, sustainability. Merits of Rain Water harvesting

(9 Lectures)

Practical : 60 Hours

PRACTICALS-SEC LAB: Renewable Energy and Energy Harvesting Lab

Sessions on the use of equipment used in the workshop, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

Demonstrations and Experiments:

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage-driven thermo-electric modules.

References

1. Non-conventional energy sources, B.H. Khan, McGraw Hill 60
2. Solar energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
3. Renewable Energy, Power for a sustainable future, Godfrey Boyle, 3rd Edn., 2012, Oxford University Press.
4. Solar Energy: Resource Assessment Handbook, P Jayakumar, 2009
5. J.Balfour, M.Shaw and S. Jarosek, Photo-voltaics, Lawrence J Goodrich (USA).

Additional Resources:

1. http://en.wikipedia.org/wiki/Renewable_energy

SEC: Engineering Design and Prototyping/Technical Drawing(32223906)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical : 60 Hours

Course Objective

The objective of this course is to introduce the students to modern visualization techniques and their applications in diverse areas including computer aided design.

Course Learning Outcomes

This course learning will enable the student to be proficient in:

- Understanding the concept of a sectional view – visualizing a space after being cut by a plane. How The student will be able to draw and learn proper techniques for drawing an aligned sections

- Understanding the use of spatial visualization by constructing an orthographic multi view drawing

- Drawing simple curves like ellipse, cycloid and spiral, Orthographic projections of points, lines and of solids like cylinders, cones, prisms and pyramids etc.

- Exposure to Computer Aided Design (CAD) and Auto CAD techniques and hence will make the student technologically savvy.

Teacher may give long duration project based on this paper.

Unit 1

Introduction: Fundamentals of Engineering design, design process and sketching: Scales and dimensioning, Designing to Standards (ISO Norm Elements/ISI), Engineering Curves: Parabola, hyperbola, ellipse and spiral.

(4 Lectures)

Unit 2

Projections: Principles of projections, Orthographic projections: straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids. Intersection and Interpenetration of solids. Isometric and Oblique parallel projections of solids.

(10 Lectures)

Unit 3

CAD Drawing: Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD specific skills (graphical user interface, create, retrieve, edit, and use symbol libraries). Use of Inquiry commands to extract drawing data. Control entity properties. Demonstrating basic skills to produce 2-D drawings. Annotating in Auto CAD with text and hatching, layers, templates and design centre, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. Basic printing and editing tools, plot/print drawing to appropriate scale.

(10 Lectures)

Unit 4

Computer Aided Design and Prototyping: 3D modeling with AutoCAD (surfaces and solids), 3D modeling with Sketchup, 3D designs, Assembly: Model Editing; Lattice and surface optimization; 2D and 3D packing algorithms, Additive Manufacturing Ready Model Creation (3D printing), Technical drafting and Documentation.

(6 Lectures)

Practicals : 60 Hours

PRACTICALS-SEC LAB: Engineering Design and Prototyping/Technical Lab

Five experiments based on the above theory.
Teacher may design at least five experiments based on the above syllabus.

References

1. Engineering Drawing, N.S. Parthasarathy and Vele Murali, 1st Edition, 2015, Oxford University Press
2. Engineering Graphic, K. Venugopal and V. Raja Prabhu, New Age International
3. Engineering Drawing, Dhananjay A Jolhe, McGraw-Hill
4. AutoCAD 2014 and AutoCAD 2014/Donnie Gladfelter/Sybex/ISBN:978-1-118-57510-9
5. Don S. Lemons, Drawing Physics, MIT Press, M A Boston, 2018, ISBN:9780262535199
6. Norton, Robert L. Design of Machinery: An Introduction to the Synthesis and
7. Analysis of Mechanisms and Machines, M A Boston, McGraw-Hill, 2007.
8. James A. Leach, AutoCAD 2017 Instructor, SDC publication, Mission, KS 2016. ISBN: 978163057029.
9. Architectural Design with Sketchup/Alexander Schreyer/John Wiley & Sons/ISBN:978-1-118-12309-6

SEC: Radiation Safety (32223907)
Credit:04 (Theory-02, Practical-02)
Theory : 30 Hours
Practical : 60 Hours

Course Objective

It is a course focused on the applications of nuclear techniques and radiation protection. It will not only enhance the skills towards the basic understanding of the radiation but will also provide the knowledge about the protective measures against the radiation exposure. It imparts all the skills required by a radiation safety officer or any job dealing with radiation such as X-ray operators, nuclear medicine dealing jobs: chemotherapists, PET MRI CT scan, gamma camera etc. operators etc.

Teacher may give long duration project based on this paper.

Course Learning Outcomes

This course will help students in the following ways:

- Awareness and understanding the hazards of radiation and the safety measures to guard against these hazards.
- Learning the basic aspects of the atomic and nuclear Physics, specially the radiations that originate from the atom and the nucleus.
- Having a comprehensive knowledge about the nature of interaction of matter with radiations like gamma, beta, alpha rays, neutrons etc. and radiation shielding by appropriate materials.
- Knowing about the units of radiations and their safety limits, the devises to detect and measure radiation, such as the Geiger-Mueller counter and scintillation counter.
- Learning radiation safety management, biological effects of ionizing radiation, operational limits and basics of radiation hazards evaluation and control, radiation protection standards, 'International Commission on Radiological Protection' (ICRP) its principles, justification, optimization, limitation, introduction of safety and risk management of radiation. nuclear waste and disposal management, brief idea about 'Accelerator driven Sub-critical System' (ADS) for waste management.
- Learning about the devices which apply radiations in medical sciences, such as MRI, PET.
- Understanding and performing experiments like Study the background radiation levels using Radiation meter, Study the Characteristics of Geiger Muller (GM) Counter, getting the plateau curve and the operating voltage and the statistical distribution of beta or gamma ray emitted from a radioactive source, Determination of gamma ray linear and mass absorption coefficient of a given material and drawing the mass absorption coefficient vs. energy curve for a given material with a number of gamma ray sources, study of beta ray energy spectrum for a given source etc.

Unit 1

Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half-life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission.

(6 Lectures)

Unit 2

Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, Interaction of Photons - Photo-electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channelling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), Interaction of Neutrons- Collision, slowing down and Moderation.

(7 Lectures)

Unit 3

Radiation detection and monitoring devices: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Geiger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.

Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter and Geiger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermoluminescent Dosimetry.

(7 Lectures)

Unit 4

Radiation safety management: Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitations, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.

(5 Lectures)

Unit 5

Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

(5 Lectures)

Practical : 60 Hours

PRACTICALS-SEC LAB: Radiation Safety Lab

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

Experiments:

Minimum five experiments need to be performed from the following,

1. Estimate the energy loss of different projectiles/ions in Water and carbon, using SRIM/TRIM etc. simulation software.
2. Simulation study (using SRIM/TRIM or any other software) of radiation depth in materials (Carbon, Silver, Gold, Lead) using H as projectile/ion.
3. Comparison of interaction of projectiles with Z_P = 1 to 92 (where Z_P is atomic number of projectile/ion) in a given medium (Mylar, Carbon, Water) using simulation software (SRIM etc).
4. SRIM/TRIM based experiments to study ion-matter interaction of heavy projectiles on heavy atoms. The range of investigations will be Z_P = 6 to 92 on Z_A = 16 to 92 (where Z_P and Z_A are atomic numbers of projectile and atoms respectively). Draw and infer appropriate Bragg Curves.
5. Calculation of absorption/transmission of X-rays, γ-rays through Mylar, Be, C, Al, Fe and Z_A = 47 to 92 (where Z_A is atomic number of atoms to be investigated as targets) using XCOM, NIST (https://physics.nist.gov/PhysRefData/Xcom/html/xcom1.html).
6. Study the background radiation in different places and identify the source material from gamma ray energy spectrum. (Data may be taken from the Department of Physics & Astrophysics, University of Delhi and gamma ray energies are available in the website http://www.nndc.bnl.gov/nudat2/).
7. Study the background radiation levels using Radiation meter .
8. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
9. Study of counting statistics using background radiation using GM counter.
10. Study of radiation in various materials (e.g. KSO_4etc.). Investigation of possible radiation in different routine materials by operating GM counter at operating voltage.
11. Study of absorption of beta particles in Aluminum using GM counter.
12. Detection of α particles using reference source & determining its half life using spark counter.
13. Gamma spectrum of Gas Light mantle (Source of Thorium).

References

1. Nuclear Physics: Principles and Applications by J Lilley, Wiley Publication, 2006.
2. Nuclear and Particle Physics by W E Burcham and M Jobes, Harlow Longman Group, 1995.
3. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
4. Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
5. Radiation detection and measurement by G F Knoll, 4th Edition, Wiley Publications, 2010.
6. Techniques for Nuclear and Particle Physics experiments by W R Leo, Springer, 1994.
7. Thermoluminescence dosimetry by A F Mcknlay, Bristol, Adam Hilger (Medical Physics Hand book 5.
8. Fundamental Physics of Radiology by W J Meredith and J B Massey, John Wright and Sons, UK, 1989.
9. An Introduction to Radiation Protection by A Martin and S A Harbisor, John Willey & Sons, Inc. New York, 1981.
10. Medical Radiation Physics by W R Hendee, Year book Medical Publishers, Inc., London, 1981.
11. Physics and Engineering of Radiation Detection by S N Ahmed, Academic Press Elsevier, 2007.

Books for Numericals:

1. Schaum's Outline of Modern Physics, McGraw-Hill, 1999.
2. Schaum's Outline of College Physics, by E. Hecht, 11th edition, McGraw Hill, 2009.
3. Modern Physics by K Sivaprasath and R Murugeshan, S Chand Publication, 2010.

Additional Resources:

1. IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3 No. GSR Part 3 (Interium) (2010); (b) Safety Standards Series No. RS-G-1.5 (2002), Rs-G-1.9 (2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).
2. AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources in radiation facilities, 2011
3. AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources., 2007.

SEC: Applied Optics (32223908)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical : 60 Hours

Course Objective

The quest to understand the 'nature of light' is a favorite inquiry of mankind since ancient times. By the advent lasers, holography, and optical fibres in twentieth century the optics now-a-days finds application in several branches of science and engineering. This paper provides the conceptual understanding of these branches of modern optics to the students.

Course Learning Outcomes

This course will help students to

- Understand basic lasing mechanism qualitatively, types of Lasers, characteristics of Laser Light, types of Lasers, and its applications in developing LED, Holography.
- Learn concept of Fourier optics and fourier transform spectroscopy.
- Understanding of basic principle and theory of Holography.
- Concept of total internal reflection.
- Characteristics of optical fibre.

Teacher may give long duration project based on this paper.

Unit 1

Photo-sources and Detectors

Lasers: an introduction, Planck's radiation law (qualitative idea), Energy levels, Absorption process, Spontaneous and stimulated emission processes, Theory of laser action, Population of energy levels, Einstein's coefficients and optical amplification, properties of laser beam, Ruby laser, He-Ne laser, and semiconductor lasers; Light Emitting Diode (LED) and photo-detectors.

(9 lectures)

Unit 2

Fourier Optics and Fourier Transform Spectroscopy (Qualitative explanation) Concept of Spatial frequency filtering, Fourier transforming property of a thin lens, Fourier Transform Spectroscopy (FTS): measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry, and forensic science.

(6 lectures)

Unit 3

Holography

Introduction: Basic principle and theory: recording and reconstruction processes, Requirements of holography- coherence, etc. Types of holograms: The thick or volume hologram, Multiplex hologram, white light reflection hologram; application of holography in microscopy, interferometry, and character recognition.

(6 lectures)

Unit 4

Photonics: Fibre Optics

Optical fibres: Introduction and historical remarks, Total Internal Reflection, Basic characteristics of the optical fibre: Principle of light propagation through a fibre, the coherent bundle, The numerical aperture, Attenuation in optical fibre and attenuation limit; Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating.

(9 lectures)

Practical : 60 Hours

PRACTICALS-SEC LAB: Applied Optics Lab

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

Experiments on Lasers:

a. To determine the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser. b. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
c. To find the polarization angle of laser light using polarizer and analyzer d. Thermal expansion of quartz using laser
e. To determine the wavelength and angular spread of laser light by using plane diffraction grating.

Experiments on Semiconductor Sources and Detectors:
a. V-I characteristics of LED
b. Study the characteristics of solid state laser c. Study the characteristics of LDR
d. Characteristics of Photovoltaic Cell/ Photodiode. e. Characteristics of IR sensor

Experiments on Fourier Optics:
a. Optical image addition/subtraction b. Optical image differentiation

c. Fourier optical filtering
d. Construction of an optical 4f system

Experiments on Fourier Transform Spectroscopy
To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

Experiments on Holography and interferometry:
a. Recording and reconstruction of holograms (Computer simulation can also be done). b. To construct a Michelson interferometer or a Fabry Perot interferometer.
c. To determine the wavelength of sodium light by using Michelson's interferometer.
d. To measure the refractive index of air.

Experiments on Fibre Optics
a. To measure the numerical aperture of an optical fibre
b. To measure the near field intensity profile of a fibre and study its refractive index profile c. To study the variation of the bending loss in a multimode fibre
d. To determine the power loss at a splice between two multimode fibre
e. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern

References

1. LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill
2. Introduction to Fourier Optics, Joseph W. Goodman, The McGraw- Hill, 1996.
3. Introduction to Fiber Optics, A. Ghatak & K. Thyagarajan, Cambridge University Press.
4. Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
5. Optical Electronics, Ajoy Ghatak and K. Thyagarajan, 2011, Cambridge University Press
6. Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
7. Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.

SEC: Weather Forecasting (32223909)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical : 60 Hours

Course Objective

The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques

Course Learning Outcomes

- Acquire basic knowledge of the elements of the atmosphere, its composition at various heights, variation of pressure and temperature with height.
- To learn basic techniques to measure temperature and its relation with cyclones and anti-cyclones.
- Knowledge of simple techniques to measure wind speed and its directions, humidity and rainfall.
- Absorption, emission and scattering of radiations in atmosphere. Radiation laws.
- Knowledge of global wind systems, jet streams, local thunderstorms, tropical cyclones, tornadoes and hurricanes.
- Knowledge of climate and its classification. Understanding various causes of climate change like global warming, air pollution, aerosols, ozone depletion, acid rain.
- Develop skills needed for weather forecasting, mathematical simulations, weather forecasting methods, types of weather forecasting, role of satellite observations in weather forecasting, weather maps etc. Uncertainties in predicting weather based on statistical analysis.
- Develop ability to do weather forecasts using input data.
- In the laboratory course, students should be able to learn: Principle of the working of a weather Station, Study of Synoptic charts and weather reports, Processing and analysis of weather data, Reading of Pressure charts, Surface charts, Wind charts and their analysis.

Teacher may give long duration project based on this paper.

Unit 1

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement

(9 Periods)

Unit 2

Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.

(4 Periods)

Unit 3

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

(3 Periods)

Unit 4

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution and its measurement, particulate matters PM 2.5, PM 10. Health hazards due to high concentration of PM2.5; aerosols, ozone depletion

(6 Periods)

Unit 5

Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

(8 Periods)

Practical : 60 Hours

PRACTICALS-SEC LAB: Weather Forecasting Lab

Real time demonstration of clouds location and their movements based on short-time animation. Satellite, for instance INSAT-3D products, can be displayed. Water vapour, cloud imagery and 3D overview of wind pattern can be demonstrated. Different wavelength channels (infra-red and visible) operations can be shown to distinguish the features. Profiles of different atmospheric parameters (temperature, humidity, wind component, etc.) can be demonstrated based on radiosonde daily launch.

Demonstrations and Experiments:

1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
    (a) To calculate the sunniest time of the year.
    (b) To study the variation of rainfall amount and intensity.
    (c) To observe the sunniest/driest day of the week.
    (d) To examine the maximum and minimum temperature throughout the year.
    (e) To evaluate the relative humidity of the day.
    (f) To examine the rainfall amount month wise.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.

4. Formats and elements in different types of weather forecasts/ warning (both aviation and non-aviation).
5. Simulation of weather system
6. Field visits to India Meteorological department and National center for medium range weather forecasting

References

1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
4. Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.
5. Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

SEC: Introduction to Physical Computing (xxx1)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical : 60 Hours

Course Objective

Physical computing is an interactive physical system that senses, processes and responds to our analog world. An embedded computer together with sensors and actuators to connect with the physical environment including human interaction, represents a common method of implementing a physical computing system.

Embedded computers have revolutionized our world. Embedded computers are much lower in cost and size and ser a single dedicated function of implementing and improving the function of the gadget. The study of elements of physical computing using embedded computers would be very beneficial towards implementing experimental setup in physics.

Course Learning Outcomes

- Understand the evolution of the CPU from microprocessor to microcontroller and embedded computers from a historical perspective.
- Understand the operation of basic electronic components and analog electronics and digital electronics building blocks including power supply and batteries.
- Be able to use CAD software to create schematic diagrams and printed circuit board layout.
- Understand how to use basic laboratory measurement equipment and instrumentation.
- Understand the Arduino ecosystem and to write simple Arduino programs (called sketches)

- Understand sensor characteristics and how to select a suitable sensor for various applications.
- Be able to read digital and analog data and produce digital and analog outputs from an embedded computer.
- Understand how to interface an embedded computer to the physical environment.
- Be able to visualize the needs of a stand alone embedded computer and to implement a simple system using Arduino.
- Be able to build and test such an embedded physical computing system.

Teacher may give long duration project based on this paper.

Unit 1

Brief overview of a computer. Evolution from CPU to Microprocessor to microcontroller. Introduction to Arduino. Overview of basic electronic components (R, L, C, diode, BJT, Mosfet etc.) and circuits, 555 timer, logic gates, logic function ICs, power supply and batteries.

(4 Lectures)

Unit 2

Capturing schematic diagrams.

(i) Using free software such as Eagle CAD.
(ii) Using basic lab instruments – DMM, oscilloscope, signal generator etc.

(6 Lectures)

Unit 3

Understanding Arduino programming. Downloading and installing Arduino IDE. Writing an Arduino sketch.

Programming fundamentals: program initialization, conditional statements, loops, functions, global variables.

(5 Lectures)

Unit 4

a) Digital Input and Output
b) Measuring time and events. Pulse Width Modulation.

(6 Lectures)

Unit 5

a) Analog Input and Output.
b) Physical Interface: sensors and actuators.

(6 Lectures)

Unit 6

a) Communication with the outside world.
b) System Integration and debugging.

(3 Lectures)

Practical : 60 Hours

PRACTICALS-SEC LAB: Introduction to Physical Computing Lab

Sessions on the construction and use of specific equipment and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

1. Hello LED: Connect a LED to a digital output pin and turn it on and off.
2. Hello Switch: Read a switch a toggle an LED when the switch is pressed and released.
3. Hello ADC: Connect a potentiometer to an ADC input and print the analog voltage on the serial monitor.
4. Hello Blink: Read a switch and changing the LED blink rate every time the switch is pressed and released.
5. Hello PWM: Write a Pulse Width Modulation code in software and vary the LED intensity.
6. Hello Random: Read a switch and every time the switch is pressed and released, generate and print a random number on the serial monitor.
7. Hello Random2: Connect a Seven Segment Display (SSD) and print the random number on this display each time a switch is pressed and released. Collect large data sample and plot relative frequency of occurrence of each 'random' number
8. Hello LCD: Connect a (16X2) LCD to an Arduino and print 'Hello World'.
9. Hello LCD2: Connect a temperature sensor to an ADC input and print the temperature on the LCD
10. Hello PWM2: Connect a RGB LED and 3 switches. Use hardware PWM feature of the Arduino and change the relative intensity of each of the LEDs of the RGB LED and generate large number of colors.

Mini Projects:

1. Connect 2 SSDs and every time a switch is pressed and released, print 2 random numbers on the two SSDs
2. Connect a switch and 4 RGB LEDs in a 'Y' configuration. Change the LED lighting patterns each time a
   (i) switch is pressed and released (total 4095 patterns possible). Arrange acrylic mirrors in a triangle and make a LED kaleidoscope using the RGB LEDs as the light source.
   (ii) Connect a photo-gate mechanism to a bar pendulum. Verify that the period of oscillation is independent of the amplitude for small amplitudes. What happens when the amplitude is large?
   (iii) Connect 8 switches and a small speaker and an audio amplifier and make a piano.
   (iv) Connect 2 sets of 3 switches for two players. Connect LCD and implement a 'rock-paper-scissors' game.

References

1. Learn Electronics with Arduino: An Illustrated Beginner's Guide to Physical Computing. Jody Culkin and Eric Hagan. Shroff Publishers. ISBN: 9789352136704.
2. Programming Arduino: Getting Started with Sketches, Second Edition. Simon Monk. McGraw-Hill Education. ISBN-10: 1259641635.
3. Physical Computing: Sensing and Controlling the Physical World with Computers, 1st Edition. Thomson. ISBN-10: 159200346X.

SEC: Numerical Analysis (xxx2)
Credit:04 (Theory-02, Practical-02)
Theory : 30 Hours
Practical : 60 Hours

Course Objective

- The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists.
- To expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems.
- To help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers.

Course Learning Outcomes

Theory:

After completing this course, student will be able to :
- approximate single and multi-variable function by Taylor's Theorem.
- Solve first order differential equations and apply it to physics problems.
- solve linear second order homogeneous and non-homogeneous differential equations with constant coefficients.
- Calculate partial derivatives of function of several variables
- Understand the concept of gradient of scalar field and divergence and curl of vector fields. perform line, surface and volume integration
- Use Green's, Stokes' and Gauss's Theorems to compute integrals

Practical:

After completing this course, student will be able to :
- design, code and test simple programs in C++ learn Monte Carlo techniques,
- fit a given data to linear function using method of least squares find roots of a given non-linear function
- Use above computational techniques to solve physics problems

Teacher may give long duration project based on this paper.

Unit 1

Errors and iterative Methods: Truncation and Round-off Errors. Floating Point Computation, Overflow and underflow. Single and Double Precision Arithmetic, Iterative Methods.

(2 Lectures)

Solutions of Algebraic and Transcendental Equations: (1) Fixed point iteration method, (2) Bisection method, (3) Secant Method, (4) Newton Raphson method, (5) Generalized Newton's method. Comparison and error estimation

(6 Lectures)

Unit 2

Interpolation: Forward and Backward Differences. Symbolic Relation, Differences of a polynomial. Newton's Forward and Backward Interpolation Formulas

(5 Lectures)

Unit 3

Least Square fitting: (1) Fitting a straight line. (2) Non-linear curve fitting: (a) Power function, (b) Polynomial of nth degree, and (c) Exponential Function. (3) Linear Weighed Least square Approximation

(5 Lectures)

Unit 4

Numerical Differentiation: (1) Newton's interpolation Formulas & (2) Cubic Spline Method, Errors in Numeric Differentiation. Maximum and Minimum values of a Tabulated Function

(4 Lectures)

Numerical Integration: Generalized Quadrature Formula. Trapezoidal Rule. Simpson's 1/3 and 3/8 Rules. Weddle's Rule, Gauss-Legendre Formula.

(4 Lectures)

Solution of Ordinary Differential Equations: First Order ODE's: solution of Initial Value problems: (1) Euler's Method, (2) Modified Euler's method

(4 Lectures)

Practical : 60 Hours

PRACTICALS-SEC LAB: Numerical Analysis Lab

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

At least 08 Experiments from the following

Algebraic and transcendental equation:
1. To find the roots of an algebraic equation by Bisection method.
2. To find the roots of an algebraic equation by Secant method.
3. To find the roots of an algebraic equation by Newton-Raphson method.
4. To find the roots of a transcendental equation by Bisection method.

5. Interpolation
    a. To find the forward difference table from a given set of data values.
    b. To find a backward difference table from a given set of data values.
6. Curve fitting

    a. To fit a straight line to a given set of data values.
    b. To fit a polynomial to a given set of data values.
    c. To fit an exponential function to a given set of data values.
7. Differentiation
    a. To find the first and second derivatives near the beginning of the table of values of (x,y).
    b. To find the first and second derivatives near the end of the table of values of (x,y).
8. Integration
    a. To evaluate a definite integral by trapezoidal rule.
    b. To evaluate a definite integral by Simpson 1/3 rule.
    c. To evaluate a definite integral by Simpson 3/8 rule.
    d. To evaluate a definite integral by Gauss Quadrature rule.
9. Differential Equations
    a. To solve differential equations by Euler's method
    b. To solve differential equations by modified Euler's method

References

1. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
2. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
3. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
4. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw Hill Pub.
5. Numerical Recipes in C++: The Art of Scientific Computing, W.H. Press et.al., 2nd Edn., 2013, Cambridge University Press.
6. An introduction to Numerical methods in C++, Brian H. Flowers, 2009, Oxford University Press.

9.4. Generic Elective-(GE)

GE: Electricity and Magnetism (32225101)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This course begins with elementary vector analysis, an essential mathematical tool for understanding static electric field and magnetic field. By the end of the course student should appreciate Maxwell's equations.

Course Learning Outcomes

At the end of this course, students will be able to

- Demonstrate Gauss law, Coulomb's law for the electric field, and apply it to systems of point charges as well as line, surface, and volume distributions of charges.
- Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
- Apply Gauss's law of electrostatics to solve a variety of problems.
- Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential.
- Demonstrate a working understanding of capacitors
- Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot- Savart and Ampere laws)
- Have brief idea of dia-, para= and ferro-magnetic materials
- Understand the concepts of induction and self-induction, to solve problems using Faraday's and Lenz's laws
- Have an introduction to Maxwell's equations.

Unit 1

Vector Analysis: Vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

(20 Lectures)

Unit 2

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

(22 Lectures)

Unit 3

Magnetism:

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials.

(10 Lectures)

Unit 4

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

(6 Lectures)

Introduction to Maxwell`s equations.

(2 Lectures)

Practical : 60 Hours

PRACTICALS-GE LAB: Electricity and Magnetism Lab

Dedicated demonstration cum laboratory sessions on the construction, functioning and uses of different electrical bridge circuits, and electrical devices like the ballistic galvanometer.

Sessions on the review of scientific laboratory report writing, and on experimental data analysis, least square fitting, and computer programme to find slope and intercept of straight line graphs of experimental data.

At least 05 experiments from the following:

1. Ballistic Galvanometer:
   - (i) Measurement of charge and current sensitivity
   - (ii) Measurement of CDR
   - (iii) Determine a high resistance by Leakage Method
   - (iv)To determine Self Inductance of a Coil by Rayleigh's Method.
2. To compare capacitances using De'Sauty's bridge.
3. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)
4. To study the Characteristics of a Series RC Circuit.
5. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor
6. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
7. To determine a Low Resistance by Carey Foster's Bridge.
8. To verify the Thevenin and Norton theorems
9. To verify the Superposition, and Maximum Power Transfer Theorems

References for Theory :

1. Vector analysis – Schaum's Outline, M.R. Spiegel, S. Lipschutz, D. Spellman, 2nd Edn., 2009, McGraw- Hill Education.
2. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.
3. Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ.Press
4. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
6. D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

References for Practical:

1. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
2. Engineering Practical Physics, S. Panigrahi and B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed.2011, Kitab Mahal.
4. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
6. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
7. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.

GE: Mathematical Physics (32225102)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists.
- To expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems.
- To help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers.

Course Learning Outcomes

Theory:

After completing this course, student will

- Learn to plot and interpret graph of the functions using the concepts of calculus.
- Be able to solve first order differential equations and apply it to physical problems.
- Have ability to solve linear second order homogeneous and non-homogeneous differential equations with constant coefficient
- Understand Vector Algebra: scalar and vector product, scalar triple product and their physical significance.
- Understand the concept of vector differentiation: gradient of scalar field, divergence and curl of vector fields. Del and Laplacian Operators
- Learn to find line, surface and volume integration
- Have understanding of Green's, Stokes' and Gauss's theorems to compute integrals.
- Apply curvilinear coordinates to problems with spherical and cylindrical symmetries.
- Understand elementary probability theory and the properties of discrete and continuous distribution functions.

Practical: 60 Hours

PRACTICALS- GE LAB: Mathematical Physics Lab

After completing this course, student will be able to :

- design, code and test simple programs in C++ learn Monte Carlo techniques,
- fit a given data to linear function using method of least squares find roots of a given non-linear function
- Use above computational techniques to solve physics problems

Unit 1

Calculus

Functions: Recapitulate the concept of functions. Plot and interpret graphs of functions using the concepts of calculus.

(2 Lectures)

First Order Differential Equations: First order differential Equations: Variable separable, homogeneous, non-homogeneous, exact and inexact differential equations and Integrating Factor. Application to physics problems.

(5 Lectures)

Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution. Particular Integral with operator method, method of undetermined coefficients and variation method of parameters. Euler differential equation and simultaneous differential equations of First and Second order.

(13 Lectures)

Unit 2

Vector Analysis

Vector Algebra: Properties of vectors. Scalar product and vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

(5 lectures)

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

(8 Lectures)

Vector Integration: Ordinary Integrals of Vectors. Double and Triple integrals, change of order of integration, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their verification (no rigorous proofs).

(14 Lectures)

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

(6 Lectures)

Unit 3
Probability and statistics:
Independent and dependent event, Conditional Probability. Bayes' Theorem, Independent random variables, Probability distribution functions, special distributions: binomial, Poisson and Normal. Sample mean and variance and their confidence intervals for Normal distribution.

(7 lectures)

Practical: 60 Hours
PRACTICALS-GE LAB: Mathematical Physics Lab

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- Highlights the use of computational methods to solve physics problems
- The course will consist of lectures (both theory and practical) in the Lab. The recommended group

size is not more than 15 students.

- Evaluation to be done not on the programming but on the basis of formulating the problem
- Aim at teaching students to construct the computational problem to be solved
- Students can use any one operating system :Linux or Microsoft Windows
- At least 12 programs must be attempted from the following covering the entire syllabus
- The list of programs here is only suggestive. Students should be encouraged to do more practice.

Topics	Descriptions with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices,

Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, single and double precision arithmetic, underflow and overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Algorithms and Flow charts	Purpose, symbols and description,
Introduction to C++	Introduction to Programming: Algorithms: Sequence, Selection and Repetition, Structured programming, basic idea of Compilers. Data Types, Enumerated Data, Conversion & casting, constants and variables, Mathematical, Relational, Logical and Bit wise Operators. Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables. Programs: • To calculate area of a rectangle • To check size of variables in bytes (Use of sizeof() Operator) • converting plane polar to Cartesian coordinates and vice versa
C++ Control Statements	if-statement, if-else statement, Nested if Structure, Else-if statement, Ternary operator,Goto statement, switch statement, Unconditional and Conditional looping, While loop, Do-while loop, For loop,nested loops, break and continue statements Programs: • To find roots of a quadratic equation if…else And if…else if..else • To find largest of three numbers • To check whether a number is prime or not • To list Prime numbers up to 1000
Random Number generator	Generating pseudo random numbers To find value of pi using Monte Carlo simulations. To integrate using Monte Carlo Method
Arrays and Functions	Sum and average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order using Bubble sort and Sequential sort, Binary search, 2-dimensional arrays, matrix operations (sum, product, transpose etc)
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha; I = I_0\left(\frac{\sin\alpha}{\alpha}\right)^2$ in optics, square root of a number.

Data Analysis and Least Square Fitting (Linear case)	Uncertainty, error and precision, mean, standard deviation and error in the mean. Combining uncertainties, Least squares method for fitting data: linear (y=ax+b), power law($y=ax^b$) and exponential ($y=ae^{bx}$). To find parameters a,b and errors in them using method of least squares.Ohms law- calculate R, Hooke's law - Calculate spring constant.
Numerical differentiation (Forward and Backward and central difference formulae – Using basic definition)	Given Position with equidistant time data calculate velocity and acceleration

References for Theory:

1. An introduction to ordinary differential equations, E.A.Coddington, 2009, PHI learning. Differential Equations, George F. Simmons, 2007, McGraw Hill.
2. Advanced Engineering Mathematics,D.G.Zill and W.S.Wright, 5 Ed.,2012,Jones and Bartlett Learning. Mathematical Physics, Goswami, 1st edition, Cengage Learning.
3. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press.
4. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
5. Mathematical Physics, A.K. Ghatak, I.C. Goyal and S.J. Chua, Laxmi Publications Private Limited (2017)
6. Vector Analysis: Schaum Outline Series, M. Spiegel, McGraw Hill Education (2017).

References for Practical:

C++ How to Program', Paul J. Deitel and Harvey Deitel, Pearson (2016)
1. 'Schaum's Outline of Programming with C++', J.Hubbard, 2000, McGraw-Hill Education
2. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
3. An introduction to Numerical methods in C^{++}, Brian H. Flowers, 2009, Oxford University Press.
4. A first course in Numerical Methods, U.M. Ascher & C. Greif, PHI Learning (2012).
5. Computational Physics, Darren Walker, 1st Edn., Scientific International Pvt. Ltd (2015).
6. Applied numerical analysis, Cutis F. Gerald and P.O. Wheatley, Pearson Education, India (2007).

Additional References for Practical

1. 'The C++ Programming Language, Bjarne Stroustrup, Addison-Wesley Professional (2013)
2. Numerical Recipes in C^{++}: The Art of Scientific Computing, W.H. Press et.al., 2ndEdn., Cambridge University Press (2013).
3. An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).
4. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

GE: Digital,Analog and Instrumentation (32225103)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This paper aims to cover the basic digital and analog electronic systems. The concept of Boolean algebra is discussed in detail and arithmetic circuits are described.
- Students will learn the physics of semiconductor devices such as p-n junction, rectifier diodes and bipolar junction transistors.
- By the end of the syllabus, students will also have an understanding of operational amplifiers and instrumentation including CRO, power supply etc.

Course Learning Outcomes

At the end of this course, students will be able to develop following learning outcomes:

- To differentiate between Analog and Digital circuits, acquire knowledge of the concepts of binary numbers, their addition, subtraction and conversion into decimal numbers.
- To explains the concepts of logic states and logic gates AND, OR, NOT, NAND, NOR, XOR and XNOR as fundamental, universal and derived gates with its utility.
- To learn how to write logical Boolean statements using the truth table, its simplification using Boolean Algebra, De-Morgan's Theorem and Karnaugh Maps specially the Sum of Products method and realize the corresponding logic circuit.
- To realize addition and subtraction of binary numbers using electronic circuits.
- To introduce the structure and operation of PN junction diodes and Bipolar Junction transistors. Also understand characteristics of different configurations, various current components and related parameters.
- To learn about the DC load line, quiescent point and biasing of voltage divider circuit.
- To analyze CE transistor amplifier using h-parameter model of the transistor.
- To distinguish ideal and practical op-amps and their electrical parameters.
- To understand various operating modes of Op-amps and its linear and non-linear application and acquire skill to design circuits for different OP-amp applications.
- To comprehend the criterion for sustained oscillations and its application in frequency determination for RC
- phase shift oscillator.
- To impart understanding of working of CRO and its usage in measurements of voltage, current, frequency and phase measurement.
- To describe working of rectifier circuits and quantitatively explain effect of capacitance filter, line and load regulation
- To explain the working of timer circuits using IC 555 and use them to develop multivibrators.
- At the successful completion of the laboratory course the student is expected to acquire hands on skills/ knowledge on the following:- Measurement of voltage and frequency

of a periodic waveform using CRO, construct all logic gates using NAND as a building block, synthesize digital circuits and simplify them using Boolean algebra, construct adders/subtractors and binary adders and Adder-Subtractors, design – amplifier using transistor, Op-Amp, Multivibrator using 555 Timer

Unit 1

Digital Circuits:

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates. NAND and NOR. Gates as Universal Gates. XOR and XNOR Gates.

(5 Lectures)

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

(6 Lectures)

Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders andFull Adders and Subtractors, 4-bit binary Adder-Subtractor.

(4 Lectures)

Unit 2

Semiconductor Devices and Amplifiers:

Semiconductor Diodes: P and N type semiconductors. PN junction and its characteristics. Static and dynamic Resistance.

(2 Lectures)

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff & Saturation regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q-point. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit of transistor. Analysis of single-stage CE amplifier using hybrid Model. Input and output Impedance. Current and Voltage gains.

(12 Lectures)

Unit 3

Operational Amplifiers (Black Box approach):

Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed-loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator,(5) Integrator, (6) Zero crossing detector.

(14 Lectures)

Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Phase-shift Oscillator.

(5 Lectures)

Unit 4

Instrumentations:

Introduction to CRO: Block diagram of CRO. Applications of CRO: (1) Study of waveform, (2) Measurement of voltage, current, frequency, and phase difference.

(3 Lectures)

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation.

(6 Lectures)

Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator.

(3 Lectures)

Practical : 60 Hours

PRACTICALS-GE LAB: Digital, Analog and Instrumentation Lab

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to specific experiments done in the lab.

At least 06 Experiments from the following

1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using CRO
2. To minimize a given (a) logic circuit and (b) Boolean equation.
3. Half adder, Full adder and 4-bit Binary Adder.
4. To design an astable multivibrator of given specifications using 555 Timer.
5. To design a monostable multivibrator of given specifications using 555 Timer.
6. To study IV characteristics of (a) PN diode, (b) Zener diode and (3) LED.
7. To study the characteristics of a Transistor in CE configuration.
8. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.
9. (a) To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.
   (b) To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.
10. To study Differential Amplifier of given I/O specification using Op-amp.
11. To investigate a differentiator made using op-amp.
12. To design a Wien Bridge Oscillator using an op-amp.

References

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Fundamentals of Digital Circuits, Anand Kumar, 4nd Edn, 2018, PHI Learning Pvt. Ltd.
3. Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
4. Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.

5. Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper,1990, PHI Learning
6. Digital Principles and Applications, A.P.Malvino, D.P.Leach and Saha, 8th Ed., 2018, Tata McGraw Hill Education
7. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
8. OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.
9. Electronic Devices and circuits, B. Kumar, S.B. Jain, 2nd Edition, 2015, PHI Learning Pvt. Ltd.
10. Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1994, Mc-Graw Hill.
11. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.

GE: Applied Dynamics
(32225104)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

Most processes encountered in nature are inherently nonlinear. This course introduces the main topics of low- dimensional nonlinear systems, with applications to a wide variety of disciplines, including physics, engineering, mathematics, chemistry, and biology. Specific topics include maps and flows in one and two dimensions, phase portraits, bifurcations, chaos, fractals and elementary fluid dynamics. Students will obtain familiarity with conce and methods in the field of dynamical systems, apply those concepts and methods to analyze dynamic models analytically and computationally, and will learn how to interpret and critically evaluate the results of those analyses. This course begins with the first order dynamical system and the idea of phase space, flows and trajectories and ends with the elementary fluid dynamics. Students will also appreciate the introduction to chaos and fractals. The emphasis of this course is to enhance the understanding of the basics of applied dynamics. By the end of this course, students should be able to solve the seen or unseen problems/numericals in applied dynamics.

Course Learning Outcomes

Upon successful course completion, a student will be able to:

- Demonstrate understanding of the concepts that underlay the study of dynamical systems. Use the analytical and computational methods covered in this course to analyze dynamical systems models.
- Understand fractals as self-similar structures by giving examples from nature and develop mathematical models for simple fractal structures.
- Understand various forms of dynamics and different routes to chaos.
- Analyze the behavior of dynamical systems (e.g. find periodic orbits and assess their stability, draw phase portraits, etc.).
- Understand basic Physics of fluids and its dynamics theoretically and experimentally and by computational simulations: Basic properties of fluids including viscosity, thermal conductivity, mass diffusivity, equation of state. Also, Physics of different types of fluid flow phenomena as well as fluid flow visualizations like streamlines, pathlines and streakline flows.
- Apply the techniques of nonlinear dynamics to physical processes drawn from a variety of scientific and engineering disciplines.
- Analyze uniform and non uniform oscillators (flows on circle)
- Draw phase portraits and interpret them in several applications from biology, physics, chemistry and engineering.

In the Lab course, students will be able to perform Simulations/Lab experiments on: Determination of the coupling Coefficients of Coupled pendulums and other coupled Oscillators, Simulation of Simple Population Models, Experimental growth and Decay, Logistic growth, Species Competition, Predator-Prey Dynamics, Simple genetic circuits, Solve rate equations numerically for some simple chemical reactions, Simulation of Fractal Formation in Deterministic Fractals, Self Similar Fractals and Fractals in nature like Trees, Coastlines and Earthquakes,Simulation of some Fluid Flow Models like Streamlines, Pathlines, and Streakline flows

Unit 1

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems: simple and damped harmonic oscillator. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems. Examples of dynamical systems – Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics.

(22 Lectures)

Unit 2

Introduction to Chaos and Fractals: Chaos in nonlinear equations - Logistic map and Lorenz equations: Dynamics from time series. Parameter dependence- steady, periodic and chaotic states.Cobweb iteration.Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions.

Self-similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure.

(18 Lectures)

Unit 3

Elementary Fluid Dynamics: Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis-concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties-viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform and non-uniform flows, viscous and inviscid flows, incompressible and compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows.

(20 Lectures)

Practical :60 Hours

PRACTICALS- GE LAB: APPLIED DYNAMICS

Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like (at least 06 experiments)

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
6. To study examples from game theory.
7. To study period doubling route to chaos in logistic map.
8. To study various attractors of Lorenz equations.
9. Computational visualization of fractal formations of Deterministic fractal.
10. Computational visualization of fractal formations of self-similar fractal.
11. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.
12. Computational Flow visualization - streamlines, pathlines, Streaklines.

References For Theory:

1. Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007.
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. Nonlinear Dynamics: Integrability, Chaos and Patterns, M. Lakshmanan and S. Rajasekar, Springer, 2003.
4. An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002.
5. Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

References For Practicals:

1. Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engi neering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer

GE: Medical Physics (32225105)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This course introduces a student to the basics of Medical Physics.

Course Learning Outcomes

This course will enable the student to

- Focus on the application of Physics to clinical medicine.
- Gain a broad and fundamental understanding of Physics while developing particular expertise in medical applications.
- Learn about the human body, its anatomy, physiology and BioPhysics, exploring its performance as a physical machine.
- Learn diagnostic and therapeutic applications like the ECG, Radiation Physics, X-ray technology, ultrasound and magnetic resonance imaging.
- Gain knowledge with reference to working of various diagnostic tools, medical imaging techniques
- Understand interaction of ionizing radiation with matter - its effects on living organisms and its uses as a therapeutic technique and also radiation safety practices.
- Imparts functional knowledge regarding need for radiological protection and the sources of an approximate level of radiation exposure for treatment purposes.
- In the laboratory course, the student will be exposed to the workings of various medical devices and getting familiarized with various detectors used in medical imaging, medical diagnostics. The hands-on experience will be very useful for the students from job perspective.

Unit 1

PHYSICS OF THE BODY-I

Basic Anatomical Terminology: Standard Anatomical Position, Planes. Familiarity with terms like- Superior, Inferior, Anterior, Posterior, Medial, Lateral, Proximal and Distal. Mechanics of the body: Skeleton, forces, and body stability. Muscles and dynamics of body movement. Physics of Locomotors Systems: joints and movements, Stability and Equilibrium. Energy household of the body: Energy balance in the body, Energy consumption of the body, Heat losses of the body, Thermal Regulation. Pressure system of body: Physics of breathing, Physics of cardiovascular system. Basics of CPR.

(8 Lectures)

Unit 2

PHYSICS OF THE BODY-II

Acoustics of the body: Nature and characteristics of sound, Production of speech, Physics of the ear, Diagnostics with sound and ultrasound. Optical system of the body: Physics of the eye. Electrical system of the body: Physics of the nervous system, Electrical signals and information transfer.

(10 Lectures)

Unit 3

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-I

X-RAYS: Electromagnetic spectrum, production of x-rays, x-ray spectra, Brehmsstrahlung, Characteristic x-ray. X-ray tubes & types: Coolidge tube, x-ray tube design, tube cooling stationary mode, Rotating anode x-ray tube, Tube rating, quality and intensity of x-ray. X-ray generator circuits, half wave and full wave rectification, filament circuit, kilo voltage circuit, types of X-Ray Generator, high frequency generator, exposure timers and switches, HT cables, HT generation.

(7 Lectures)

RADIATION PHYSICS: Radiation units exposure, absorbed dose, units: rad, gray, relative biological effectiveness, effective dose, inverse square law. Interaction of radiation with matter Compton & photoelectric effect, Rem & Sievert, linear attenuation coefficient. Radiation Detectors: Thimble chamber, condenser chambers, Geiger Muller counter, Scintillation counters and Solid State detectors, ionization chamber, Dosimeters, survey methods, area monitors, TLD, Semiconductor detectors.

(7 Lectures)

Unit 4

MEDICAL IMAGING PHYSICS: Evolution of Medical Imaging, X-ray diagnostics and imaging, Physics of nuclear magnetic resonance (NMR), NMR imaging, MRI Radiological imaging, Ultrasound imaging, Physics of Doppler with applications and modes, Vascular Doppler. Radiography: Filters, grids, cassette, X-ray film, film processing, fluoroscopy. Computed tomography scanner- principle & function, display, generations, mammography. Thyroid uptake system and Gamma camera (Only Principle, function and display).

(9 Lectures)

RADIATION ONCOLOGY PHYSICS: External Beam Therapy (Basic Idea): Telecobalt, Conformal Radiation Therapy (CRT), 3DCRT, IMRT, Image Guided Radiotherapy, EPID, Rapid Arc, Proton Therapy, Gamma Knife, Cyber Knife. Contact Beam Therapy (Basic Idea): Brachytherapy-LDR and HDR, Intra Operative Brachytherapy. Radiotherapy, kilo voltage machines, deep therapy machines, Telecobalt machines ,Medical linear accelerator. Basics of Teletherapy units, deep x- ray, Telecobalt units, medical linear accelerator, Radiation protection, external beam characteristics, dose maximum and build up – bolus, percentage depth dose, tissue maximum ratio and tissue phantom ratio, Planned target Volume and Gross Tumour Volume.

(9 Lectures)

Unit 5

RADIATION AND RADIATION PROTECTION: Principles of radiation protection, protective materials-radiation effects , somatic, genetic stochastic and deterministic effect. Personal monitoring devices: TLD film badge , pocket dosimeter, OSL dosimeter. Radiation dosimeter. Natural radioactivity, Biological effects of radiation, Radiation monitors. Steps to reduce radiation to Patient, Staff and Public. Dose Limits for Occupational workers and Public. AERB: Existence and Purpose.

(5 Lectures)

Unit 6

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-II

Diagnostic nuclear medicine: Radiopharmaceuticals for radioisotope imaging, Radioisotope imaging equipment, Single photon and positron emission tomography. Therapeutic nuclear medicine: Interaction between radiation and matter Dose andisodose in radiation treatment. Medical Instrumentation: Basic Ideas of Endoscope and Cautery, Sleep Apnea and Cpap Machines, Ventilator and its modes.

(5 Lectures)

Practical : 60 Hours

PRACTICALS- GE LAB: Medical Physics Lab

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

1. Understanding the working of a manual Hg Blood Pressure monitor, Stethoscope and to measure the Blood Pressure.
2. Basic Process of doing CPR
3. Understanding the working of a manual optical eye-testing machine and to learn eye testing procedure.
4. Correction of Myopia (short sightedness) using a combination of lenses on an optical bench/breadboard.
5. Correction of Hypermetropia/Hyperopia (long sightedness) combination of lenses on an optical bench/breadboard.
6. To learn working of Thermo luminescent dosimeter (TLD) badges and measure the background radiation.
7. Familiarization with Geiger-Muller (GM) Counter & to measure background radiation
8. Familiarization with Radiation meter and to measure background radiation.
9. Familiarization with the Use of a Vascular Doppler.

References

1. Medical Physics, J.R. Cameron and J.G. Skofronick, Wiley (1978)
2. Basic Radiological Physics Dr. K.Thayalan- Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi (2003)
3. Christensen's Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)

4. Physics of the human body, Irving P. Herman, Springer (2007).
5. Physics of Radiation Therapy: F M Khan - Williams and Wilkins, 3 rd edition (2003)
6. The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)
7. Handbook of Physics in Diagnostic Imaging: R.S. Livingstone: B.I. Publication Pvt Ltd.

GE: Mechanics (32225201)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This course begins with the review of Vectors and Differential equations and ends with the Special Theory of Relativity. Students will also appreciate the Gravitation, Rotational Motion and Oscillations. The emphasis of this course is to enhance the basics of mechanics. By the end of this course, students should be able to solve the seen or unseen problems/numericals in vectors, differential equations and mechanics.

Course Learning Outcomes

Upon completion of this course, students are expected to understand the following concepts which would help them to appreciate the application of the fundamental concepts to the analysis of simple, practical situations related to the real world:

- Understand the role of vectors and coordinate systems in Physics.
- Learn to solve Ordinary Differential Equations: First order, Second order Differential Equations with constant coefficients'
- Understand laws of motion and their application to various dynamical situations.
- Learn the concept of Inertial reference frames and Galilean transformations. Also, the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
- Understand the analogy between translational and rotational dynamics, and application of both motions simultaneously in analyzing rolling with slipping.
- Understand variable mass system and dynamics of a system of particles.
- Able to write the expression for the moment of inertia about the given axis of symmetry for different uniform mass distributions.
- Understand the phenomena of elastic and in-elastic collisions
- Understand angular momentum of a system of particle.
- Apply Kepler's law to describe the motion of planets and satellite in circular orbit through the study of law of Gravitation.

- Understand concept of Geosynchronous orbits
- Explain the phenomenon of simple harmonic motion.
- Understand special theory of relativity - special relativistic effects and their effects on the mass and energy of a moving object.
- In the laboratory course, after acquiring knowledge of how to handle measuring instruments (like screw gauge, vernier callipers, Travelling microscope) student shall embark on verifying various principles learnt in theory. Measuring ‘g’ using Bar Pendulum, Kater pendulum and measuring elastic constants of materials, viscous properties of liquids etc.

Unit 1

Vectors: Vector algebra. Derivatives of a vector with respect to a parameter. Scalar and vector products of two, three and four vectors. Gradient, divergence and curl of vectors fields. Polar and Axial vectors.

(5 Lectures)

Ordinary Differential Equations:1st order homogeneous differential equations, exact and non-exact differential equations, 2nd order homogeneous and non-homogenous differential equations with constant coefficients (Operator Method Only).

(8 Lectures)

Unit 2

Laws of Motion: Review of Newton's Laws of motion. Dynamics of a system of particles. Concept of Centre of Mass, determination of center of mass for discrete and continuous systems having cylindrical and spherical symmetry (1-D, 2-D, 3-D objects).

(6 Lectures)

Work and Energy: Motion of rocket. Work-Energy theorem for conservative forces. Force as a gradient of Potential Energy. Conservation of momentum and energy. Elastic and in-elastic Collisions.

(5 Lectures)

Unit 3

Rotational Dynamics: Angular velocity, Angular momentum, Torque, Conservation of angular momentum, Moment of Inertia. Theorem of parallel and perpendicular axes. Calculation of Moment of Inertia of discrete and continuous objects (1-D, 2-D and 3-D). Kinetic energy of rotation. Motion involving both translation and rotation.

(10 Lectures)

Unit 4

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statements only). Satellite in circular orbit and applications. Geosynchronous orbits.

(5 Lectures)

Unit 5

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Compound pendulum. Differential equations of damped oscillations and its solution.

(7 Lectures)

Unit 6

Special Theory of Relativity: Frames of reference. Gallilean Transformations. Inertial and Non-inertial frames. Outcomes of Michelson Morley's Experiment. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic transformation of velocity. Relativistic variation of mass. Mass-energy equivalence. Transformation of Energy and Momentum.

(14 Lectures)

Note: Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate.

Practical: 60 Hours

PRACTICALS- GE LAB: Mechanics Lab

Demonstration cum laboratory sessions on the construction and use of Vernier callipers, screw gauge and travelling microscope, and necessary precautions during their use.

Sessions and exercises on the least count errors, their propagation and recording in final result up to correct significant digits, linearization of data and the use of slope and intercept to determine unknown quantities.

Session on the writing of scientific laboratory reports, which may include theoretical and practical significance of the experiment performed, apparatus description, relevant theory, necessary precautions to be taken during the experiment, proper recording of observations, data analysis, estimation of the error and explanation of its sources, correct recording of the result of the experiment, and proper referencing of the material taken from other sources (books, websites, research papers, etc.)

At least 05 experiments from the following:

1. Measurements of length (or diameter) using Vernier calliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the motion of the spring and calculate (a) Spring constant and, (b) g.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique.
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
10. To determine the elastic constants of a wire by Searle's method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater's Pendulum.

References for Theory:

1. University Physics.FW Sears, MW Zemansky & HD Young13/e, 1986.
2. Addison-Wesley Mechanics Berkeley Physics course, vol.1
3. Charles Kittel,et.al. 2007, Tata McGraw-Hill Physics.
4. Resnick, Halliday & Walker 9/e, 2010, Wiley.
5. Engineering Mechanics, Basudeb Bhattacharya, 2nd ed., 2015, Oxford University Press.
6. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

References for Practical:

1. Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
3. Engineering Practical Physics, S. Panigrahi and B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
4. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
6. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
7. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.

GE: Elements of Modern Physics (32225202)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This course introduces modern development in Physics that ushered in relativity and quantum physics which not only revolutionized mankind's understanding of time, space, atomic and sub-atomic structures that make up the matter around us, but also led to fascinating developments in technology that are being witnessed all around us. Beginning with technological marvels like electronics, spectroscopy, semiconductor based devices, IC chips, lasers, harnessing of nuclear energy, satellite communication, atomic clocks, GPS, space travel, scanni tunneling microscope, nano-materials, nano- technology, CCDs, etc. modern physics brought forth useful tools in our daily lives like laptop computers, mobile phones, laser pointers, LEDs, LCD screens, so on and so forth. Therefore, the objective of this course is to teach the physical and mathematical foundations necessary for learning various topics in modern physics. Starting from Planck's law, this course introduces experimental observation of photo-ejection of electrons, ide of wave-particle duality as well as Bohr model of atoms and, then it develops the formulation of Schrodinger equation and the idea of probability interpretation associated with wave-functions. It also introduces basic underlying concepts involved in laser physics as well as that in nuclear physics, so cruci for high energy physics, nuclear technology and astrophysics.

Course Learning Outcomes

After getting exposure to this course, the following topics would be learnt:

- Main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
- The theory of quantum measurements, wave packets and uncertainty principle.
- The central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and time independent cases, probability density and the normalization techniques, skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier.
- The properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.
- To calculate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrinos and its properties and role in theory of beta decay.
- Fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
- The spontaneous and stimulated emission of radiation, optical pumping and population inversion. Three level and four level lasers. Ruby laser and He-Ne laser in details. Basic lasing.
- In the laboratory course, the students will get opportunity to measure

(i) Planck's constant by more than one method, verify photoelectric effect and determination of the work Function of a metal, determine e/m of electron.
(ii) Ionization potential of atoms, wavelength of the emission lines in the spectrum of Hydrogen atom, absorption lines in the rotational spectrum of molecules.
(iii)The wavelength of Laser sources by single and Double slit experiment and the wavelength and angular spread of He-Ne Laser using plane diffraction grating

Unit 1

Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets.Group and Phase velocities and relation between them. Double-slit experiment with electrons. Probability. Wave amplitude and wave functions.

(12 Lectures)

Unit 2

Position measurement : gamma ray microscope thought experiment; Wave-particle duality leading to Heisenberg uncertainty principle; Uncertainty relations involving canonical pair of variables: Derivation from Wave Packets; Impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle: origin of natural width of emission lines as well as estimation of the mass of the virtual particle that mediates a force from the observed range of the force

(7 Lectures)

Unit 3

Two-slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

(10 Lectures)

Unit 4

One dimensional infinitely rigid box : energy eigenvalues, eigenfunctions and their normalization; Quantum dot as an example; Quantum mechanical scattering and tunneling in one dimension : across a step potential & across a rectangular potential barrier. Lasers: Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion.

(14 Lectures)

Unit 5

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, N-Z graph, Liquid Drop model: semi-empirical mass formula and binding energy.

(6 Lectures)

Unit 6

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. Fission and fusion: mass deficit, relativity and generation of energy; Fission : nature of fragments and emission of neutrons. Fusion and thermonuclear reactions driving stellar evolution (brief qualitative discussions).

(11 Lectures)

Practical : 60 Hours

PRACTICALS- GE LAB: Elements of Modern Physics Lab

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the modern physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 06 experiments from the following:

1. Measurement of Planck's constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine angular spread of He-Ne laser using plane diffraction grating

References for Theory :

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill.
3. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, Cengage Learning 2010.
4. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
5. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
6. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill.

References for Practical:

1. Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4 th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I.Prakash & amp; Ramakrishna, 11 th Edn, 2011,Kitab Mahal.
4. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
6. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
7. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.

Additional Resources:

1. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore,2003, McGraw Hill
2. Thirty years that shook physics: the story of quantum theory, George Gamow, Garden City, NY : Doubleday, 1966
3. Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019
4. Quantum Theory, David Bohm, Dover Publications, 1979
5. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.

GE: Solid State Physics (32225203)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This syllabus begins with introduction to the basic concepts and principles to understand the various properties exhibited by condensed matter, especially solids. These properties depend on the chemical constituents making the particular solid and their arrangement in the crystal. A semi-classical approach is used to introduce various models, from toy model to a higher level, suitable to explain the particular property exhibited by the solid. The syllabus is specifically designed to guide the students to learn how to create a theoretical model for a particular property and appreciate the beauty that lies in these solids through their properties.

Course Learning Outcomes

On successful completion of the module students should be able to

- Elucidate the concept of lattice, crystals and symmetry operations.
- Explain the concepts such as the reciprocal lattice and the Brillouin zone and the dynamics of atoms and electrons in solids.
- Explain diffraction of X-rays by solids to determine the crystal structure.
- Understand the elementary lattice dynamics and its influence on the properties of materials.
- Describe the main features of the physics of electrons in solids.
- Understand the origin of energy bands, and how they influence electronic behavior.
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids.
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability.
- Understand the basics of phase transitions and the preliminary concept and experiments related to superconductivity in solid.
- To carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

Unit 1

Crystal Structure and Elementary Lattice Dynamics: State of matter: Gas, Liquid, Solid. Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Unit Cell. Types of Lattices. Miller Indices. Reciprocal Lattice. Diffraction of X-rays by Crystals. Bragg's Law. Lattice Vibrations: Linear Monoatomic and Diatomic Chains.

(12 Lectures)

Unit 2

Elementary band theory: Band Gap. Conductors, Semiconductors and insulators. P-and N- type Semiconductors. Conductivity of Semiconductors, mobility, Hall Effect, Hall coefficient.

(10 Lectures)

Unit 3

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferro- magnetic materials. Classical Langevin Theory of dia– and Para- magnetic Domains.Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

(12 Lectures)

Unit 4

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility.Polarizability.Clausius Mossotti Equation. Classical Theory of Electric Polarizability

(8 Lectures)

Unit 5

Applications: Piezoelectric, Pyroelectric, Ferroelectric, Ferromagnetic materials

(3 Lectures)

Unit 6

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors.

(5 Lectures)

Practical : 60 Hours

PRACTICALS- GE LAB: Solid State Physics Lab

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the solid state physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.
At least 06 experiments from the following:

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
2. To measure the Magnetic susceptibility of solids.
3. To determine the Coupling Coefficient of a piezoelectric crystal.
4. To study the dielectric response of materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique.
6. To determine the refractive index of a dielectric material using SPR technique.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.

8. To draw the BH curve of Iron (Fe) using solenoid & determine the energy loss from Hysteresis loop.
9. To measure the resistivity of a semiconductor (Ge) with temperature (up to 150^0C) by four-probe method and determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.
12. Measurement of change in resistance of a semiconductor with magnetic field.

References for Theory:

1. Introduction to Solid State Physics, Charles Kittel, 8th Ed.,2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed.,2006, Prentice-Hall of India.
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
5. Elementary Solid State Physics, M.Ali Omar, 2006, Pearson
6. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

Reference for Practical:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
4. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
6. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
7. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.

GE: Embedded System: Introduction to Microcontroller (32225204)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- In this course, students will learn about the 8051 I/O port programming, various addressing modes.
- Students will have a thorough understanding of Timer and counter programming, Serial port programming with and without interrupt and interfacing 8051 microcontroller to peripherals.

Course Learning Outcomes

This is a course to familiarize/ introduce students to designing and developing embedded systems. It provides the students with an introductory coverage of embedded systems. The learning outcomes of the course are:

- Knowledge of the major components that constitute an embedded system.
- Understand what is a microcontroller, microcomputer embedded system.
- Description of the architecture of a 8051 microcontroller.
- Write simple programs for 8051 microcontroller in C language.
- Understand key concepts of 8051 microcontroller systems like I/O operations, interrupts, programming of timers and counters.
- Interfacing of 8051 microcontroller with peripherals
- Understand and explain concepts and architecture of embedded systems
- Implement small programs to solve well-defined problems on an embedded platform.
- Develop familiarity with tools used to develop an embedded environment
- Learning to use the Arduino Uno (an open source microcontroller board) in simple applications.

Unit 1

Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges and design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers.

(4 Lectures)

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions.

(12 Lectures)

Unit 2

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of 8051 microcontroller, I/O port pins description and their functions, I/O port programming in 8051, (Using Assembly Language), I/O programming: Bit manipulation.

(4 Lectures)

Programming of 8051: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic & logic instructions, 8051 programming in C:- for time delay and I/O operations and manipulation, for arithmetic & logic operations, for ASCII and BCD conversions.

(12 Lectures)

Unit 3

Timer & counter programming: Programming 8051 timers, counter programming.

(3 Lectures)

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051.

(6 Lectures)

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing.

(2 Lectures)

Unit 4

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging.

(3 Lectures)

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry.

(8 Lectures)

Unit 5

Introduction to Arduino: Pin diagram and description of Arduino UNO. Basic programming and applications.

(6 Lectures)

Practical :60 Hours

PRACTICALS- GE LAB: Embedded System: Introduction to Microcontroller Lab

Sessions on the use of specific equipment and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

At least 06 experiments based on 8051 microcontroller from the following:

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's .
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
9. To toggle '1234' as '1324' in the seven segment LED display.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.

References

1. Embedded Systems: Architecture, Programming & Design, Raj Kamal, 2008, Tata McGraw Hill
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A.Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education
3. Embedded Systems: Design & applications, S.F. Barrett, 2008, Pearson Education
4. Embedded Microcomputer systems: Real time interfacing, J.W.Valvano 2011, Cengage Learning
5. Embedded Systems & Robots, Subrata Ghoshal, 2009, Cengage Learning
6. Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.
7. Microprocessors and Microcontrollers, Krishna Kant, 2nd Edition, 2016. PHI learning Pvt. Ltd.

GE: Biological Physics (32225205)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

- To familiarize the students with the basic facts and ideas of biology from a quantitative perspective.
- To show them how ideas and methods of physics enrich our understanding of biological systems at diverse length and time scales.
- To give them a flavour of the interface between biology, chemistry, physics and mathematics.

Course Learning Outcomes

After completing this course, students will

- Know basic facts about biological systems, including single cells, multicellular organisms and ecosystems from a quantitative perspective.
- Gain familiarity with various biological processes at different length and time scales, including molecular processes, organism level processes and evolution.
- Be able to apply the principles of physics from areas such as mechanics, electricity and magnetism, thermodynamics, statistical mechanics, and dynamical systems to understand certain living processes.
- Gain a systems level perspective on organisms and appreciate how networks of interactions of many components give rise to complex behavior.
- Perform mathematical and computational modelling of certain aspects of living systems.
- Acquire mastery of the fundamental principles and applications of various branches of Physics in understanding biological systems.
- Learn relevance of chemistry principles and thermodynamics in understanding energy transfer mechanism and protein folding in biological systems.
- Get exposure to complexity of life at i) the level of Cell, ii) level of multi cellular organism and iii) at macroscopic system – ecosystem and biosphere
- Get exposure to models of evolution.

Unit 1

Overview:
The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Allometric scaling laws.

(6 Lectures)

Unit 2

Molecules of life:
Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling. Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell. Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways to be studied analytically and computationally.

(18 Lectures)

Unit 3

Molecular motion in cells:
Random walks and applications to biology: Diffusion; models of macromolecules. Entropic forces: Osmotic pressure; polymer elasticity. Chemical forces: Self assembly of amphiphiles. Molecular motors: Transport along microtubules. Flagellar motion: bacterial chemotaxis.

(22 Lectures)

Unit 4

The complexity of life:
At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Metabolic, regulatory and signaling networks in cells. Dynamics of metabolic networks; the stoichiometric matrix. The implausibility of life based on a simplified probability estimate, and the origin of life problem. At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cellular differentiation and development. Brain structure: neurons and neural networks. Brain as an information processing system. At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self- sustaining ecosystems.

(20 Lectures)

Unit 5

Evolution:
The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.

(9 Lectures)

References

1. Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman &Co, NY, 2004)
2. Physical Biology of the Cell (2nd Edition); Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)
3. An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)
4. Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

GE: Waves and Optics (32225310)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

The physics and mathematics of wave motion underlie many important phenomena. The water wave on the sea, the vibration of a violin string, etc. can all be described in a similar way. Light too, often displays properties that are wave-like. The course is aimed at equipping the students with the general treatment of waves. This begins with explaining ideas of oscillations and simple harmonic motion and go on to look at the physics of travelling and standing wav This understanding applies to have a more elaborate analysis for sound waves and this further considers a numb of phenomena in which the wave properties of light are important such as interference, diffraction, and polarization with emphasis of examples as seen in daily life.

Course Learning Outcomes

On successfully completing the requirements of this course, the students will have the skill and knowledge to:

- Understand Simple harmonic oscillation and superposition principle.
- Understand superposition of a range of collinear and mutually perpendicular simple harmonic motions and their applications.
- Understand the importance of classical wave equation in transverse and longitudinal waves and solving a range of physical systems on its basis.
- Understand different types of waves and their velocities: Plane, Spherical, Transverse, Longitudinal.
- Understand Concept of normal modes in transverse and longitudinal waves: their frequencies and configurations
- Understand the concept of temporal and spatial coherence.
- Understand Interference as superposition of waves from coherent sources derived from same parent source
- Demonstrate understanding of Interference experiments: Young's Double Slit, Fresnel's biprism, Llyod's Mirror, Newton's Rings.
- Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from apertures
- Understand Fraunhoffer Diffraction from a slit.
- In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Rings experiment, Fresnel Biprism etc. Resolving power of optical equipment can be learnt first hand.

- The motion of coupled oscillators, study of Lissajous figures and behaviour of transverse, longitudinal waves can be learnt in this laboratory course.

Unit 1

Superposition of Two Collinear Harmonic oscillations: Simple harmonic motion (SHM). Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

(6 Lectures)

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.

(2 Lectures)

Unit 2

Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.

(8 Lectures)

Unit 3

Sound: Sound waves, production and properties. Intensity and loudness of sound. Decibels. Intensity levels. General idea of musical notes and musical scale. Acoustics of buildings (General idea).

(6 Lectures)

Unit 4

Wave Optics: Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle. Interference: Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Newton's Rings: measurement of wavelength and refractive index.

(14 Lectures)

Unit 5

Diffraction: Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period
zone analysis.

(14 Lectures)

Unit 6

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization (General idea).

(7 Lectures)

Practical : 60 Hours

PRACTICALS- GE LAB: Waves and Optics Lab

Dedicated demonstration cum laboratory session on the construction, and use of spectrometer and lasers, and necessary precautions during their use.

Session on experimental data analysis, theory of random errors and the standard error in the mean. Use of error bars in graphs and errors in slope and intercept.

At least 05 experiments from the following:

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda 2$ – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster`s focussing; determination of angle of prism.
5. To determine the Refractive Index of the Material of a Prism using Sodium Light.
6. To determine Dispersive Power of the Material of a Prism using Mercury Light
7. To determine the value of Cauchy Constants.
8. To determine the Resolving Power of a Prism.
9. To determine wavelength of sodium light using Fresnel Biprism.
10. To determine wavelength of sodium light using Newton's Rings.
11. To determine the wavelength of Laser light using Diffraction of Single Slit.
12. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating.
13. To determine the Resolving Power of a Plane Diffraction Grating. To determine the wavelength of laser light using diffraction grating.

References for Theory :

1. Vibrations and Waves, A.P. French, 1stEd., 2003, CRC press.
2. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
3. OPTICS, (2017), 6th Edition, Ajoy Ghatak, McGraw-Hill Education, New Delhi;
4. Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
5. Principles of Optics, B.K. Mathur, 1995, Gopal Printing
6. Fundamentals of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications
7. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley.

References for Practical:

1. Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann
3. Educational Publishers

4. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
5. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
6. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
7. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
8. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.

GE: Quantum Mechanics (32225311)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

After learning the elements of modern physics, students would be poised to learn more advanced topics like ho to solve the Schrodinger equation for spherically symmetric potentials. Then, in this course, eigenvalues and eigen functions of the Hamiltonian as well as the orbital angular momentum would be studied. Furthermore, application of Schrodinger equation to various quantum mechanical problems would be taken up. The spin angular momentum of electrons would also be introduced in the course. It is recommended that students crediting this course should taken have taken earlier the courses - (1)"Mathematical Physics" and (2) "Elements of Modern Physics" , in order to perform well in this course.

Course Learning Outcomes

The Students will be able to learn the following from this course:

- Familiarization with quantum mechanics formulation.
- After an exposition of inadequacies of classical mechanics in explaining microscopic phenomena, quantum theory formulation is introduced through Schrodinger equation.
- The interpretation of wave function of quantum particle and probabilistic nature of its location and subtler points of quantum phenomena are exposed to the student.
- Methods to solve time-dependent and time-independent Schrodinger equation
- Through understanding the behavior of quantum particle encountering a barrier potential, the student gets exposed to solving non-relativistic hydrogen atom, for its spectrum and eigenfunctions.
- Physics of atomic interactions with electric and magnetic field - Space quantization, electron spin, spin angular momentum, Larmor's theorem, Zeeman effect etc.

- Concept of spectral notations, LS-, JJ- coupling, symmetric & antisymmetric wave functions and Pauli's exclusion principle in in many electron atomic systems
- Application to atomic systems
- In the laboratory course, with the exposure in computational programming in the computer lab, the student will be in a position to solve Schrodinger equation for ground state energy and wave functions of various simple quantum mechanical one-dimensional and three dimensional potentials.

Unit 1

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function: Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

(12 Lectures)

Unit 2

Time independent Schrodinger equation: Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

(12 Lectures)

Unit 3

General discussion of bound states in an arbitrary potential: continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator: energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.

(10 Lectures)

Unit 4

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground and first excited states; Orbital angular momentum quantum numbers l and m; s, p, d shells.

(10 Lectures)

Unit 5

Atoms in Electric and Magnetic Fields: Electron angular momentum. Angular momentum quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Normal Zeeman Effect: Electron Magnetic Moment and Magnetic Energy.

(8 Lectures)

Unit 6

Many electron atoms: Pauli's Exclusion Principle. Symmetric and Anti-symmetric Wave Functions. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Spin-orbit coupling in atoms-L-S and J-J couplings.

(8 Lectures)

Practical : 60 Hours

PRACTICALS- GE LAB: Quantum Mechanics Lab

Use C/C ++ /Scilab for solving the following problems based on Quantum Mechanics like:

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E] where\, V(r) = \frac{-e^2}{r}$$

where m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511×10^6 eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

$$V(r) = \frac{-e^2}{r} e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVÅ)^{1/2}$, m = 0.511×10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

For the anharmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100 MeV fm^{-2}, b = 0, 10, 30 MeV fm^{-3}. In these units, $c\hbar$ = 197.3 MeV fm. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2\mu}{h^2}[V(r) - E]$$

Where μ is the reduced mass of the two-atom system for the Morse potential

$$V(r) = D(e^{-2ar'} - e^{-ar'}), r' = \frac{r - r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.
Take: m = $940x10^6$ eV/c^2, D = 0.755501 eV, α = 1.44, r_0 = 0.131349 Å

Where μ is the reduced mass of the two-atom system for the Morse potential

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.
Take: m = $940x10^6$ eV/c^2, D = 0.755501 eV, α = 1.44, r_o = 0.131349 Å

Additional laboratory based experiments: (optional)

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting

References

1. Modern Quantum Mechanics, J.J Sakurai, Revised Edition, 1994, Addision-Wesley.
2. Introduction to Quantum Mechanics, David J. Griffiths, Second Edition, 2006, Pearson Education.
3. QUANTUM MECHANICS: Theory and Applications, (2019), (Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi.
4. Quantum Mechanic Concepts and Applications, Nouredine Zettili, Second Edition 2001, John Wiley & Sons, Ltd.
5. Introduction to Quantum Mechanics, Volume-I, C. Cohen-Tannoudgi, B. Diu, F. Laloe, 1977, Wiley-VCH.

Reference Books for the practicals:

1. Schaum & Outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Pub.
2. Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et.al., 3 rd Edn., 2007, Cambridge University Press.
3. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3 rd Edn., 122 Cambridge University Press
4. Elementary Numerical Analysis, K.E. Atkinson, 3 rd Ed. 2007,Wiley India Edition

5. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández.2014 Springer
6. Quantum Mechanics, Leonard I. Schiff, 3 rd Edn. 2010, Tata McGraw Hill.
7. A Text book of Quantum Mechanics, P.M.Mathews& K.Venkatesan, 2nd Ed., 2010, McGraw Hill.
8. Quantum Mechanics, Brian H. Bransden and C. Charles Jean Joachain, 2000, Prentice Hall.

Additional Resources:

1. Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019
2. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications, 1966.

GE: Communication System (32225312)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This paper aims to describe the concepts of electronics in communication.
- Communication techniques based on Analog Modulation, Analog and digital Pulse Modulation including PAM, PWM, PPM, ASK, PSK, FSK are described in detail.
- Communication and Navigation systems such as GPS and mobile telephony system are introduced.

Course Learning Outcomes

At the end of this course, students will be able to develop following learning outcomes:

- This paper aims to describe the concepts of electronics in communication. In this course, students will receive an introduction to the principle, performance and applications of communication systems.
- Students will learn the various means and modes of communication. They will gain an understanding of fundamentals of electronic communication system and

electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.

- They will gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Students will be able to analyze different parameters of analog communication techniques.
- They will learn the need of sampling and different sampling techniques where they can sample analog signal.
- Students will learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- They will gain an in-depth understanding of different concepts used in a satellite communication system.
- They will study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- Students will understand evolution of mobile communication generations 2G, 3G, and 4G with their characteristics and limitations.
- This paper will essentially connect the text book knowledge with the most popular communication technology in real world.
- Students will apply the theory that they have learned in the theory class to gain hands on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to construct TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.

Unit 1

Electronic communication: Introduction to communication – means and modes. Power measurements (units of power). Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals.

(4 Lectures)

Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Single Sideband (SSB) systems, advantages of SSB transmission, Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver.

(12 Lectures)

Unit 2

Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing).

(9 Lectures)

Unit 3

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

(10 Lectures)

Unit 4

Satellite Communication– Introduction, need, Geosynchronous satellite orbits, geostationary satellite
advantages of geostationary satellites. Transponders (C - Band), Uplink and downlink, path loss, Satellite visibility, Ground and earth stations. Simplified block diagram of earth station.

(10 Lectures)

Unit 5

Mobile Telephony System– Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). GPS navigation system (qualitative idea only)

(15 Lectures)

Practical: 60 Hours

PRACTICALS- GE LAB: Communication System Lab

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to specific experiments done in the lab.

At least 05 experiments from the following

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
    - (i) To study Time Division Multiplexing (TDM)
    - (ii) To study Pulse Amplitude Modulation (PAM)
    - (iii) To study Pulse Width Modulation (PWM)
    - (iv) To study Pulse Position Modulation (PPM)
    - (v) To study ASK, PSK and FSK modulators

References

1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2. Advanced Electronics Communication Systems- Tomasi, 6^{th} Edn.Prentice Hall.
3. Modern Digital and Analog Communication Systems, B.P. Lathi, 4^{th} Edition, 2011, Oxford University Press.
4. Electronic Communication systems, G. Kennedy, 3^{rd} Edn., 1999, Tata McGraw Hill.
5. Principles of Electronic communication systems – Frenzel, 3^{rd} edition, McGraw Hill
6. Communication Systems, S. Haykin, 2006, Wiley India
7. Electronic Communication system, Blake, Cengage, 5^{th} edition.
8. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press
9. Introduction to Communication systems, U. Madhow, 1^{st} Edition, 2018, Cambridge University Press

GE: Verilog and FPGA based system design (32225313)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This paper provides a review of combinational and sequential circuits such as multiplexers, demultiplexers, decoders, encoders and adder circuits.
- Evolution of Programmable logic devices such as PAL, PLA and GAL is explained.
- At the end of the syllabus, students will be able to understand the modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design.

Course Learning Outcomes

This paper discusses the fundamental Verilog concepts in-lieu of today's most advanced digital design techniques. At the end of this course, students will be able to develop following learning outcomes:

- Understand the steps and processes for design of logic circuits and systems.
- Be able to differentiate between combinational and sequential circuits.
- Be able to design various types of state machines.
- Be able to partition a complex logic system into elements of data-path and control path.
- Understand various types of programmable logic building blocks such as CPLDs and FPGAs and their tradeoffs.
- Be able to write synthesizable Verilog code.
- Be able to write a Verilog test bench to test various Verilog code modules.

- Be able to design, program and test logic systems on a programmable logic device (CPLD or FPGA) using Verilog.

Unit 1

Digital logic design flow. Review of combinational circuits. Combinational building blocks: multiplexors, demultiplexers, decoders, encoders and adder circuits. Review of sequential circuit elements: flip-flop, latch and register. Finite state machines: Mealy and Moore. Other sequential circuits: shift registers and counters. FSMD (Finite State Machine with Datapath): design and analysis. Microprogrammed control. Memory basics and timing. Programmable Logic devices.

(**20 Lectures**)

Unit 2

Evolution of Programmable logic devices. PAL, PLA and GAL. CPLD and FPGA architectures. Placement and routing. Logic cell structure, Programmable interconnects, Logic blocks and I/O Ports. Clock distribution in FPGA. Timing issues in FPGA design. Boundary scan.

(**20 Lectures**)

Unit 3

Verilog HDL: Introduction to HDL. Verilog primitive operators and structural Verilog Behavioral Verilog. Design verification. Modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design examples in Verilog.

(**20 lectures**)

Practical: 60 Hours

PRACTICALS- GE LAB: Verilog and FPGA based System Design Lab

Session on the construction and use of experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to specific experiments done in the lab

At least 08 experiments from following.

1. Write code to realize basic and derived logic gates.
2. Half adder, Full Adder using basic and derived gates.
3. Half subtractor and Full Subtractor using basic and derived gates.
4. Design and simulation of a 4 bit Adder.
5. Multiplexer (4x1) and Demultiplexer using logic gates.
6. Decoder and Encoder using logic gates.
   (i) Clocked D, JK and T Flip flops (with Reset inputs)
   (ii) 3-bit Ripple counter
   (iii) To design and study switching circuits (LED blink shift)
   (iv) To design traffic light controller.
   (v) To interface a keyboard
   (vi) To interface a LCD using FPGA
   (vii) To interface multiplexed seven segment display.

(viii) To interface a stepper motor and DC motor.
(ix) To interface ADC 0804.

References

1. Lizy Kurien and Charles Roth. Principles of Digital Systems Design and VHDL.Cengage Publishing. ISBN-13: 978-8131505748
2. Palnitkar, Samir, Verilog HDL. Pearson Education; Second edition (2003).
3. Ming-Bo Lin. Digital System Designs and Practices: Using Verilog HDL and FPGAs. Wiley India Pvt Ltd. ISBN-13: 978-8126536948
4. Zainalabedin Navabi. Verilog Digital System Design. TMH; 2nd edition.ISBN-13: 978-0070252219
5. Wayne Wolf. FPGA Based System Design. Pearson Education.
6. S. K. Mitra, Digital Signal processing, McGraw Hill, 1998
7. VLSI design, Debaprasad Das, 2nd Edition, 2015, Oxford University Press.
8. D.J. Laja and S. Sapatnekar, Designing Digital Computer Systems with Verilog, Cambridge University Press, 2015.
9. U. Meyer Baese, Digital Signal Processing with FPGAs, Springer, 2004
10. Verilog HDL primer- J. Bhasker. BSP, 2003 II edition

GE: Nano Materials and Applications (32225314)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This course introduces briefly the basic concepts of Quantum Mechanics, essential for this course. Schrodinger wave equation and its applications to simple problems are discussed. The concepts were then used to understand the idea of quantum confinement which is central to the understanding of the optical properties and electron transport phenomenon in nanostructures. Synthesis, characterization and applications of nanomaterials are discussed.

The main prerequisite is an introductory course in Solid State Physics and Quantum Mechanics.

Course Learning Outcomes

On successful completion of the module students should be able to

- Explain the difference between nanomaterials and bulk materials and their properties.
- Explain various methods for the synthesis/growth of nanomaterials.
- Explain the role of confinement on the density of state function and so on the various properties exhibited by nanomaterials compared to bulk materials.
- Explain the various characterization tools required to study the structural, optical and electrical properties of nanomaterials.
- Analyze the data obtained from the various characterization techniques.
- Explain the concept of Quasi-particles such as excitons and how they influence the optical properties.
- Explain the direct and indirect bandgap semiconductors, radiative and non-radiative processes and the concept of luminescence.
- Explain the structure of 2DEG system and its importance in quantum transport experiments.
- Explain the Interger Quantum Hall Effect and the concept of Landau Levels, and edge states in conductance quantization.
- Explain the conductance quantization in 1D structure and its difference from the 2DEG system.
- Explain the necessary and sufficient conditions required to observe coulomb blockade, single electron transistor and the scope of these devices.
- Explain how MEMS and NEMS devices are produced and their applications.
- Explain why nanomaterials exhibit properties which are sometimes very opposite, like magnetic, to their bulk counterparts.

Unit 1

Brief Historical achievements: Use of nanoparticle by artisans or craftsman’s in glass wares, pottery etc. Introduction to naturally occurring nanoparticles/nanostructures (explore the surroundings). Discussion on Michael Faraday’s experiment with the gold films.

Discussion on the visionary articles: (1) There's Plenty of Room at the Bottom: An Invitation to Enter a New Field of Physics by Prof. Richard P. Feynman, (2) Room at the Bottom, Plenty of Tyranny at the Top by Prof. Karl Hess.

(8 Lectures)

Unit 2

Basic Quantum Mechanics: Idea about particles as wave, electron interference experiment, superposition principle, position (or amplitude), and momentum. Wave-particle duality, uncertainty principle, energy quantization, Schrodinger equation. Applications of Schrodinger equation (**qualitative**): The free particle, potential step, rectangular potential barrier and the tunnel effect, free and bound states of a particle in square well potential, particle in a box (3D) problem.

(10 Lectures)

Unit 3

Basic Introduction to solids and Nanoscale Systems: Classification of solids into crystalline and amorphous materials, classification based on conductivity (range of values) as metals, semiconductors and insulators, idea of bandgap and its consequences on optical and electrical properties, electrons as free particles for current conduction (I = nevA), introduce bulk (3D) and nanomaterials {thin films (2D), nanowires (1D) nanodots or quantum dots (0D)} with an example of the colour of say Gold metals and its nanoparticles. Bulk materials Density of states function and its implication on electrical properties, Band structure and density of states function for nanoscale materials (Quantitative for 2D, 1D, 0D), Applications of quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences on electronic and optical properties.
(DOS function can be introduced through the population census survey, the plot of no. of persons (in millions) vs age)

(17 Lectures)

Unit 4

Synthesis and Characterization (Qualitative): Top down and Bottom up approach, Photolithography. Ball milling. Spin coating, Vacuum deposition: Physical vapor deposition (PVD): Thermal evaporation, Sputtering, Pulsed Laser Deposition (PLD), electric arc deposition for CNT, C_{60}, grapheme, Chemical vapor deposition (CVD). Preparation through colloidal methods (Metals, Metal Oxide nanoparticles), MBE growth of quantum dots. **Structure and Surface morphology:** X-Ray Diffraction (XRD). Scanning Electron Microscopy (SEM), Scanning Tunnel Microscopy (STM) (must discuss Quantum Corral). Transmission Electron Microscopy (TEM). **Spectroscopy:** UV-Vis spectroscopy. (Emphasis should be on to discuss data and plots gathered from these techniques)

(10 Lectures)

Unit 5

Optical and Electron Transport Properties: Bandgap tuning as a function of particle size (discuss results of oxide and metal nanoparticles) Radiative processes: General formalization-absorption, emission and luminescence. Defects and impurities. Idea about time and length scale, diffusive and ballistic transport of electrons in nanostrcutures, Discuss interesting experiments (no derivations) (1) Charging effect, Coulomb blockade effect (2) Single electron device.

(10 Lectures)

Unit 6

Applications (Qualitative): based on optical, electrical and magnetic properties of nanoparticles, nanowires and thin films in electronic industry, medical industry, beauty products, Micro Electromechanical Systems (MEMS).

(5 Lectures)

Practical: 60 Hours

PRACTICALS- GE LAB: Nano Materials and Applications Lab

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the nano physics lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

At least 06 experiments from the following:

1. Synthesis of metal (Au/Ag) nanoparticles by chemical route and study/observe its optical absorption properties.
2. Synthesis of semiconductor (CdS/ZnO/TiO2/Fe2O3etc) nanoparticles and study/observe its optical absorption properties.
3. Study the XRD pattern of nanoparticles and estimation the particle size.
4. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
5. To study/observe the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study its XRD and UV-Visible spectra.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si/Ge and study its V-I characteristic.

Reference For Theory:

1. Solid State Physics, M. A. Wahab, 2011, Narosa Publications
2. Solid State Physics by J. R. Hall and H. E. Hall, 2^{nd} edition (2014) Wiley
3. Quantum Mechanics by S. P. Singh, M. K. Bagde and K. Singh, S. Chand and Company Ltd.
4. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
5. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1^{st} edition (2003) Wiley India Pvt. Ltd.
6. S.K. Kulkarni, Nanotechnology: Principles & Practices 2^{nd} edition (2011) (Capital Publishing Company)

7. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
8. Electronic transport in mesoscopic systems by SupriyoDatta (1997) Cambridge University Press.
9. Electronic transport in mesoscopic systems by SupriyoDatta (1997) Cambridge University Press.
10. Fundamentals of molecular spectroscopy by C. N. Banwell and E. M. McCASH, 4th edition, McGraw Hill.

Reference for Practical:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt.Ltd.
2. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company).
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).

Additional Resources:

1. Quantum Transport in semiconductor nanostructures by Carla Beenakker and HenK Van Houten (1991) (available at arXiv: cond-mat/0412664) open source
2. Sara cronewett Ph.D. thesis (2001).

GE: Thermal Physics and Statistical Mechanics (32225415)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This course will introduce Thermodynamics, Kinetic theory of gases and Statistical Mechanics to the students. Th primary goal is to understand the fundamental laws of thermodynamics and it's applications to various thermo dynamical systems and processes. This coursework will also enable the students to understand the connection between the macroscopic observations of physical systems and microscopic behaviour of atoms and molecule through statistical mechanics.

Course Learning Outcomes

At the end of this course, students will

- Learn the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations. They are also expected to learn Maxwell's thermodynamic relations.
- Know the fundamentals of the kinetic theory of gases, Maxwell-Boltzman distribution law, equipartition of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
- Learn about the black body radiations, Stefan- Boltzmann's law, Rayleigh-Jean's law and Planck's law and their significances.
- Learn the quantum statistical distributions, viz., the Bose-Einstein statistics and the Fermi-Dirac statistics.
- In the laboratory course, the students are expected to: Measure of Planck's constant using black body radiation, determine Stefan's Constant, coefficient of thermal conductivity of a bad conductor and a good conductor, determine the temperature co-efficient of resistance, study variation of thermo emf across two junctions of a thermocouple with temperature etc

Unit 1

Laws of Thermodynamics: Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law, Entropy, Carnot‟s cycle & theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

(22 lectures)

Unit 2

Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell‟s relations and applications - Joule-Thomson Effect, Clausius Clapeyron Equation, Expression for ($C_P – C_V$), C_P/C_V, TdS equations.

(10 lectures)

Unit 3

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases.

(10 lectures)

Unit 4

Theory of Radiation: Blackbody radiation, Spectral distribution, Derivation of Planck's law, Deduction of Wien's law, Rayleigh-Jeans Law, Stefan Boltzmann Law & Wien's displacement law from Planck's law.

(6 lectures)

Unit 5

Statistical Mechanics: Macrostate and Microstate, phase space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann law, Fermi-Dirac distribution law - Bose-Einstein distribution law - comparison of three statistics.

(12 lectures)

Practical : 60 Hours

PRACTICALS- GE LAB: Thermal Physics and Statistical Mechanics Lab

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the thermal physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne’s constant flow method.
2. Measurement of Planck’s constant using black body radiation.
3. To determine Stefan’s Constant.
4. To determine the coefficient of thermal conductivity of Cu by Searle’s Apparatus.
5. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton’s disc method.
6. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
7. To study the variation of thermo emf across two junctions of a thermocouple with temperature.

References for Theory:

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill
4. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L.Salinger. 1988, Narosa.
5. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

References for Practicals:

1. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11thEdition, 2011, Kitab Mahal, New Delhi.
3. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.
4. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
6. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
7. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.

GE: Digital Signal Processing (32225416)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals.
- This paper also highlights the concept of filters and realization of Digital Filters.
- At the end of the syllabus, students will develop the understanding of Discrete and fast Fourier Transform.

Course Learning Outcomes

In this course, students will be able to develop a thorough understanding of the central elements of discrete time signal processing theory and correlate this theory with the real-world signal processing applications. At the end of this course, students will be able to develop following learning outcomes:

- Students will learn basic discrete-time signal and system types, convolution sum, impulse and frequency response concepts for linear time-invariant (LTI) systems.
- The student will be in position to understand use of different transforms and analyze the discrete time signals and systems. They will learn to analyze a digital system using z-transforms and discrete time Fourier transforms, region of convergence concepts, their properties and perform simple transform calculations,.
- The student will realize the use of LTI filters for filtering different real world signals. The concept of transfer function and difference-Equation System will be introduced. Also, they will learn to solve Difference Equations.
- Students will develop an ability to analyze DSP systems like linear-phase, FIR, IIR, All-pass, averaging and notch Filter etc.
- Students will be able to understand the discrete Fourier transform (DFT) and realize its implementation using FFT techniques.
- Students will be able to learn the realization of digital filters, their structures, along with their advantages and disadvantages. They will be able to design and understand different types of digital filters such as finite & infinite impulse response filters for various applications.

Unit 1

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response.

(10 Lectures)

Unit 2

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property.
The z-Transform: Bilateral (Two-Sided) z-Transform, Inverse z-Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of-Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the z-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations.

(15 Lectures)

Unit 3

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters.

(5 Lectures)

Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing.

(10 Lectures)

Unit 4

Fast Fourier Transform: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (WN), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms.

(5 Lectures)

Unit 5

Realization of Digital Filters: Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; Direct-Form I.
Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators.

Infinite Impulse Response Digital Filter: Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method.

(15 Lectures)

Practical : 60 Hours

PRACTICAL-GE LAB: Digital Signal Processing Lab

At least 06 experiments from the following using Scilab/Matlab. Introduction to Numerical computation software Scilab/Matlab be introduced in the lab.

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence $u(n)$, (c) ramp sequence $r(n)$, (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \le n \le 50$.
2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for N = 5
$$x(n) = rect\left(\frac{n}{2N}\right) = \Pi\left(\frac{n}{2N}\right) = \begin{cases} 1 & -N \le n \le N \\ 0 & otherwise \end{cases}$$
3. An LTI system is specified by the difference equation
$$y(n) = 0.8y(n-1) + x(n)$$

(a) Determine $H\left(e^{jw}\right)$

(b) Calculate and plot the steady state response $y_{ss}(n)$ to
$$x(n) = \cos(0.5\pi n)u(n)$$

4. Given a casual system
$$y(n) = 0.9y(n-1) + x(n)$$

(a) Find $H(z)$ and sketch its pole-zero plot

(b) Plot the frequency response $\left|H\left(e^{jw}\right)\right|$ and $\angle H\left(e^{jw}\right)$

5. Design a digital filter to eliminate the lower frequency sinusoid of $x(t) = \sin 7t + \sin 200t$. The sampling frequency is $f_s = 500\ Hz$. Plot its pole zero diagram, magnitude response, input and output of the filter.

6. Let $x(n)$ be a 4-point sequence:
$$x(n) = \{1, \underset{\uparrow}{1}, 1, 1\} = \begin{cases} 1 & 0 \le n \le 3 \\ 0 & otherwise \end{cases}$$

Compute the DTFT $X\left(e^{jw}\right)$ and plot its magnitude

(a) Compute and plot the 4 point DFT of $x(n)$

(b) Compute and plot the 8 point DFT of $x(n)$ (by appending 4 zeros)

(c) Compute and plot the 16 point DFT of $x(n)$ (by appending 12 zeros)

7. Let $x(n)$ and $h(n)$ be the two 4-point sequences,
$$x(n) = \{1, \underset{\uparrow}{2}, 2, 1\}$$
$$h(n) = \{1, -1, \underset{\uparrow}{-1}, 1\}$$

Write a program to compute their linear convolution using circular convolution.

8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.
9. Design an FIR filter to meet the following specifications:

passband edge $F_p = 2\ KHz$
stopband edge $F_s = 5\ KHz$
Passband attenuation $A_p = 2\ dB$
Stopband attenuation $A_s = 42\ dB$
Sampling frequency $F_s = 20\ KHz$

10. The frequency response of a linear phase digital differentiator is given by

$$H_d\left(e^{jw}\right) = jwe^{-j\tau w}|w| \leq \pi$$

Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response.

Reference Books:

1. Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press, India.
2. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
3. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
4. Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.
5. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
6. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.

GE: Nuclear and Particle Physics (32225417)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

The objective of the course is to impart the understanding of the sub atomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches Physics and societal application. The course will focus on the developments of problem based skills.

Course Learning Outcomes

- The acquire knowledge can be applied in the areas of nuclear, medical, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.
- Learn the ground state properties of a nucleus – the constituents and their properties, mass number and atomic number, relation between the mass number and the radius and the mass number, average density, range of force, saturation property, stability curve, the concepts of packing fraction and binding energy, binding energy per nucleon vs. mass number graph, explanation of fusion and fission from the nature of the binding energy graph.
- To be able to understand the basic properties of nuclei as well as knowledge of experimental assessments, the concept of binding energy and n-z curves and their significance
- Know about the nuclear models and their roles in explaining the ground state properties of the nucleus –(i) the liquid drop model, its justification so far as the nuclear properties are concerned, the semi-empirical mass formula, (ii) the shell model, evidence of shell structure, magic numbers, predictions of ground state spin and parity, theoretical deduction of the shell structure, consistency of the s hell structure with the Pauli exclusion principles.
- To appreciate the formulations and contrasts between different nuclear models such as Liquid drop and Shell Model and evidences in support.
- Radioactivity and decay laws. A detailed analysis, comparison and energy kinematics of alpha, beta and gamma decays. Outlines of Gamow's theory of alpha decay and Pauli's theory of beta decay with the neutrino hypothesis, the electron capture, the fine structure of alpha particle spectrum, the Geiger-Nuttall law, the radioactive series.
- Familiarization with different types of nuclear reactions, Q- values, compound and direct reactions.
- To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter and neutron interaction with matter.
- The students are expected to learn about the principles and basic constructions of particle accelerators such as the Van-de-Graff generator, cyclotron, betatron and synchrotron. They will acquire knowledge about Accelerator facilities in India along with a comparative study of a range of detectors and accelerators which are building blocks of modern day instruments.

- Learn about the detectors of nuclear radiations- the Geiger-Mueller counter, the scintillation counter, the photo-multiplier tube, the solid state and semiconductor detectors.
- It will acquaint students with the nature and magnitude of different forces, particle interactions, families of sub- atomic particles with the different conservation laws, concept of quark model.

Unit 1

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density, matter density (experimental determination of each), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/Z plot, angular momentum, parity, magnetic moment, electric moments.

(10 Lectures)

Unit 2

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons), Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure and the basic assumption of shell model.

(11 Lectures)

Unit 3

Radioactivity decay: Decay rate and equilibrium (Secular and Transient)(a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains. (b) β- decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (c)

Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion.

(10 Lectures)

Unit 4

Nuclear Reactions: Types of Reactions, units of related physical quantities, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

(8 Lectures)

Unit 5

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter (photoelectric effect, Compton scattering, pair production), neutron interaction with matter.

(9 Lectures)

Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

(9 Lectures)

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons (Principal, construction, working, advantages and disadvantages).

(7 Lectures)

Unit 6

Particle physics: Particle interactions (concept of different types of forces), basic features, Cosmic Rays, types of particles and its families, Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness) concept of quark model, color quantum number and gluons.

(11 Lectures)

References

1. Basic Ideas and concepts in Nuclear Physics : An introductory Approach by K Heyde, Third edition, IOP Publication, 1999.
2. Nuclear Physics by S. N. Ghoshal, First edition, S. Chand Publication, 2010.
3. Concepts of Nuclear Physics by Bernard L Cohen, Tata McGraw Hill Publication, 1974.
4. Introductory Nuclear Physics by Kenneth S, Krane, Wiley-India Publication, 2008
5. Nuclear Physics : principles and applications by John Lilley, Wiley Publication, 2006.
6. Physics and Engineering of Radiation Detection by Syed Naeem Ahmed, Academic Press Elsevier, 2007.
7. Introduction to Modern Physics by Mani & Mehta, Affiliated East-West Press, 1990.
8. Introduction to elementary particles by David J Griffiths, Wiley, 2008.
9. Modern Physics by Serway, Moses and Moyer, CENGAGE LEARNING, 2012.

Additional Resources:

1. Radiation detection and measurement, G.F. Knoll, John Wiley & Sons, 2010.
2. Technique for Nuclear and Particle Physics experiments by William R Leo, Springer, 1994.
3. Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education, 2009.
4. Nuclear Physics "Problem-based Approach" Including MATLAB by Hari M. Aggarwal, PHI Learning Pvt. Ltd. (2016)

Numerical Books :

1. Schaum's Outline of Modern Physics, McGraw-Hill Education, 1999.
2. Modern Physics by R. Murugaeshan. S.Chand Publication, 2010.

GE: Astronomy and Astrophysics (32225418)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

This General Elective course is meant to introduce undergraduate students of the University of Delhi to the wonders of the Universe. Students will understand how astronomers over millennia have come to understand mysteries of the universe using laws of geometry and physics, and more recently chemistry and biology. They will learn about diverse set of astronomical and astrophysical phenomenon, from the daily and yearly motion of stars and planets in the night sky which they can observe themselves, to the expansion of the universe deduced from the latest observations and cosmological models. The course presupposes school level understanding of mathematics and physics.

Course Learning Outcomes

Students completing this course gain

- An understanding of different types of telescopes, diurnal and yearly motion of astronomical objects, and astronomical coordinate systems and their transformations.
- Brightness scale for stars, types of stars, their structure and evolution on HR diagram.
- Components of Solar System and its evolution
- The large scale structure of the Universe and its history
- Distribution of chemical compounds in the interstellar medium and astrophysical conditions necessary for the emergence and existence of life.

Unit 1

Introduction to Astronomy and Astronomical Scales: Wonders of the Universe, Overview of the Night Sky, Diurnal and Yearly motions of the Sun, Stars and Constellations. Size, Mass, Density and Temperature of Astronomical objects, Basic concepts of Positional Astronomy: Celestial Sphere, Astronomical Coordinate Systems, Horizon System, Equatorial System, Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar, Astronomical Time Systems (LMT, UT, UTC)

(15 Lectures)

Unit 2

Basic Parameters of Stars: Determination of Distance by Parallax Method; Aberration, Proper Motion, Brightness, Radiant Flux and Luminosity, Apparent and Absolute Magnitude Scales, Distance Modulus; Determination of Temperature and Radius of a Star; Stellar Spectra, Atomic Spectra Revisited, Spectral Types and their Temperature

Dependence, Black Body Approximation, Luminosity Classification, H R Diagram and Relations Between Stellar Parameters

(15 Lectures)

Unit 3

Observational Tools and Physical Principles: Observing through the atmosphere (Scintillation, Seeing , Atmospheric Windows and Extinction) Basic Optical Definitions for Telescopes: Magnification, Light Gathering Power, Limiting magnitude, Resolving Power, Diffraction Limit, Optical and Radio Telescopes, Current Indian Observatories. Virial Theorem for N Particle Systems and Applications, Mean Molecular Weight of Stellar Gas, Stellar Energy Sources.

(15 Lectures)

Unit 4

Sun and the Solar Family: Solar Parameters, Sun's Internal Structure, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity.
The Solar Family: Facts and Figures, Origin of the Solar System, The Nebular Model. Tidal Forces and Planetary Rings, Extra-Solar Planets.

(8 Lectures)

Unit 5

Milky Way: Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constants, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Properties of and around the Galactic Nucleus. Interstellar molecules.

(10 lectures)

Unit 6

Cosmology and Astrobiology: Standard Candles (Cepheids and SNe Type1a), Cosmic Distance Ladder, Olber's Paradox, Hubble's Expansion, History of the Universe, Chemistry of Life, Origin of Life, Chances of Life in the Solar System, Exoplanets

(12 Lectures)

References

1. Seven Wonders of the Cosmos, Jayant V Narlikar, Cambridge University Press
2. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
3. The Physical Universe: An Introduction to Astronomy, F H Shu, University Science Books
4. Astrophysics Stars and Galaxies K D Abhyankar, Universities Press
5. ModernAstrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
6. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.
7. Baidyanath Basu, An introduction to Astrophysics, Second printing, Prentice - Hall of India Private limited, New Delhi,2001.
8. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th

Edition, Saunders College Publishing.
9. Explorations: Introduction to Astronomy, Thomos Arny and Stephen Schneider, 2014, 7th edition, McGraw Hill
10. The Molecular Universe, A.G.G.M. Tielens, Reviews of Modern Physics, Vol 85, July September, 2013

GE: Atmospheric Physics (32225419)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

This paper aims to describe the characteristics of earth's atmosphere and also its dynamics.

Course Learning Outcomes

- Good knowledge of Earth's atmosphere, its composition, effective temperature, Greenhouse effect. Hydrostatic equation and atmospheric thermodynamics. Local winds, clouds, fog, monsoon, cyclones, sea breeze and land breeze and thunderstorms etc.
- Essential knowledge of the instruments of meteorological observation, meteorological processes and systems.
- Understanding atmospheric dynamics, fundamental forces, conservation laws, rotating coordinate system and equations of motion. Circulation, vorticity, various types of circulations, atmospheric oscillations: biannual, annual and semi-annual oscillations.
- Understanding atmospheric waves. Surface water waves, accoustic waves, buoyancy waves, atmospheric gravity waves (AGW) and its propagation in non-homogeneous medium, Lamb and Rossy waves and their propagation in 3-dimension. Wave absorption and non linear effects.
- Skills to use atmospheric Radar and Lidar to study atmospheric phenomenon, basic knowledge of Radars and Lidars including Radar equation and signal processing. Develop numerical skills to do data analysis from Radar and Lidar.
- Knowledge of the classification and properties of aerosols, their concentrations and size distribution. Production and removal of aerosols. Radiative and health effects and observation techniques for aerosols.
- Understanding the absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Boyer-Lambert law, optical phenomenon in atmosphere. Basics of radiometry.
- In the laboratory course through computer simulations students will learn Atmospheric wave using Dispersion relations, Kelvin waves, Rossby waves and Mountain waves.

(i) Offline and if possible online processing of RADAR data: VHF RADAR, X-band RADAR, UHF RADAR.
(ii) Offline and Online processing of LIDAR data
(iii) Study of Radiosonde data and its interpretation in terms of the atmospheric parameters
(iv) Interpretation of the satellite data using radio Occultation technique
(v) Time Series Analysis of Temperature using long term data and implications for climate change.

Unit 1

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms.

(12 Lectures)

Unit 2

Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics.

(12 Lectures)

Unit 3

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration

(12 Lectures)

Unit 4

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.

(12 Lectures)

Unit 5

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars.

(12 Lectures)

Practical: 60 Hours

PRACTICALS- GE LAB: Atmospheric Physics Lab

Scilab/C ++ based simulations experiments based on Atmospheric Physics problems like (at least 05 experiments)

1. Numerical Simulation for atmospheric waves using dispersion relations
   (a) Atmospheric gravity waves (AGW) (b) Kelvin waves
   (c) Rossby waves and mountain waves
2. Offline and online processing of radar data
   (a) VHF radar,
   (b) X-band radar, and
   (c) UHF radar
3. Offline and online processing of LIDAR data 1374. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.
4. Handling of satellite data and plotting of atmospheric parameters using different techniques such as radio occultation technique
5. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change
6. PM 2.5 measurement using compact instruments
7. Field visits to National center for medium range weather forecasting, India meteorological departments, and ARIES Nainital to see onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

References

1. Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3 rd edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014.

GE: Physics of Earth (32225420)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

This course familiarizes the students with the origin of universe and role of earth in the solar system.

Course Learning Outcomes

At the end of this course student will be able to

- Have an overview of structure of the earth as well as various dynamical processes occurring on it.
- Develop an understanding of evolution of the earth.
- Apply physical principles of elasticity and elastic wave propagation to understand modern global seismology as a probe of the Earth's internal structure.
- Understand the origin of magnetic field, Geodynamics of earthquakes and the description of seismic sources; a simple but fundamental theory of thermal convection; the distinctive rheological behaviour of the upper mantle and its top.
- Explore various roles played by water cycle, carbon cycle, nitrogen cycles in maintaining steady state of earth leading to better understanding of the contemporary dilemmas (climate change, bio diversity loss, population growth, etc.) disturbing the Earth
- In the tutorial section, through literature survey on the various aspects of health of Earth, project work / seminar presentation, the students will be able to appreciate need to 'save' Earth.

Unit 1

The Earth and the Universe: (a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography . Introduction to various branches of Earth Sciences. (b) General characteristics and origin of the Universe. The Big Bang Theory. Age of the universe and Hubble constant. Formation of Galaxies. The Milky Way galaxy, Nebular Theory, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Titius-Bode law. Asteroid belt. Asteroids: origin types and examples. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age. (c) Energy and particle fluxes incident on the Earth. (d) The Cosmic Microwave Background.

(17 Lectures)

Unit 2

Structure: (a) The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior?
(b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems. (c) The Atmosphere: layers, variation of temperature with altitude, adiabatic lapse rate, variation of density and pressure with altitude, cloud formation (d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers, permafrost.

(18 Lectures)

Unit 3

Dynamical Processes: (a) **The Solid Earth**: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; types of plate movements, hotspots; sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Seismic waves, Richter scale, geophones. Volcanoes: types products and distribution. (b) **The Hydrosphere**: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, tend – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis. (c) **The Atmosphere**: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones and anti-cyclones. Climate: i. Earth's temperature and greenhouse effect. ii. Paleoclimate and recent climate changes. iii. The Indian monsoon system. (d) **Biospher**e: Water cycle, Carbon cycle. The role of cycles in maintaining a steady state.

(18 Lectures)

Unit 4

Evolution: Stratigraphy: Introduction and types, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Time line of major geological and biological events. Introduction to geochronological methods and their application in geological studies. Radiometric dating: Advantages & disadvantages of various isotopes. History of development of concepts of uniformitarianism, catastrophism and neptunism. Various laws of stratigraphy. Introduction to the geology and geomorphology of Indian subcontinent. Origin of life on Earth, Role of the biosphere in shaping the environment. Future of evolution of the Earth and solar system: Death of the Earth (Probable causes).

(18 Lectures)

Unit 5

Disturbing the Earth – Contemporary dilemmas (a) Human population growth. (b) Atmosphere: Green house gas emissions, climate change, air pollution. (c) Hydrosphere: Fresh water depletion. (d) Geosphere: Chemical effluents, nuclear waste. (e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

(4 Lectures)

References

1. Planetary Surface Processes, H. Jay Melosh, 2011, Cambridge University Press.

2. Consider a Spherical Cow: A course in environmental problem solving, John Harte, University Science Books
3. Holme's Principles of Physical Geology, 1992, Chapman & Hall.
4. Planet Earth, Cosmology, Geology and the Evolution of Lifeand Environment, C. Emiliani, 1992, Cambridge University Press.
5. The Blue Planet:An Introduction to Earth System Science, Brian J. Skinner, Stephen C. Portere, 1994, John Wiley & Sons.
6. Physics of the Earth, Frank D. Stacey, Paul M. Davis, 2008, Cambridge University Press.
7. Fundamentals of Geophysics, William Lowrie, 1997, Cambridge University Press.
8. The Solid Earth: An Introduction to Global Geophysics, C. M. R. Fowler, 1990, Cambridge University Press.
9. The Earth: A Very Short Introduction, Martin Redfern, 2003, Oxford University Press.
10. Galaxies: A Very Short Introduction, John Gribbin, 2008, Oxford University Press.
11. Climate Change: A Very Short Introduction, Mark Maslin, 3 rd Edition, 2014, Oxford University Press.
12. The Atmosphere: A Very Short Introduction, Paul I. Palmer, 2017, Oxford University Press.
13. IGNOU Study material: PHE 15 Astronomy and Astrophysics Block 2

ANNEXURE-1A

Steering Committee
LOCF (CBCS) Undergraduate Physics courses revision 2019
Department of Physics & Astrophysics, University of Delhi

1. Prof. Sanjay Jain – HoD (Chairman)
2. Prof. A. G. Vedeshwar – (Coordinator)
3. Prof. Vinay Gupta – (Convener)
4. Prof. Debajyoti Choudhury
5. Prof. P. Das Gupta
6. Prof. S. Annapoorni
7. Prof. H.P. Singh
8. Prof. T.R. Seshadri
9. Prof. Anjan Dutta
10. Prof. S.K. Mandal
11. Prof. Kirti Ranjan
12. Dr. G.S. Chilana (Department of Physics, Ramjas College)
13. Dr. Mallika Verma (Department of Physics, Miranda House)
14. Dr. Anuradha Gupta (Department of Physics, SGTB Khalsha College)
15. Dr. Sangeeta D. Gadre (Department of Physics, Kirori Mal College)
16. Dr. Jacob Cherian (Department of Physics, St. Stephens' College)
17. Dr. Vandana Luthra (Department of Physics, Gargi College)
18. Dr. Mamta (Department of Physics, SGTB Khalsa College)
19. Dr. P.K. Jha (Department of Physics, Deen Dyal Upadhyaya College)
20. Dr. Sanjay Kumar (Department of Physics, St. Stephens' College)
21. Dr. Abhinav Gupta (Department of Physics, St. Stephen's College)
22. Dr. Monika Tomar (Department of Physics, Miranda House)
23. Dr. Roshan Kshetrimayum (Department of Physics, Kirori Mal College)
24. Mr. Ashish Tyagi (Department of Physics, Swami Shraddhanand College)
25. Dr. Shalini Lumb Talwar (Department of Physics, Maitreyi College)
26. Dr. Shiva Upadhyay (Department of Physics, Swami Shraddhanand College)
27. Dr. Divya Haridas (Department of Physics, Keshav Mahavidyalaya)
28. Dr. Chetana Jain (Department of Physics, Hansraj College)

ANNEXURE 1B

Subject working groups
LOCF (CBCS) Undergraduate Physics courses revision 2019
Department of Physics & Astrophysics, University of Delhi

Group	Papers	Name of faculty	Role	College
I	• Waves and Optics (Hons. core /GE) • Electricity and magnetism (Hons. core/GE) • Electromagnetic theory (Hons. core) • Electricity and magnetism (Prog. core) • Waves and Optics (Prog. core) • Electrical circuits and Networks (SEC) • Applied Optics (SEC) • Introduction to Physical Computing (SEC)	Prof. Kirti Ranjan	Coordinator	Department of Physics & Astrophysics
		Dr. Sangeeta D. Gadre	Convenor	Kirori Mal College
		Dr. Pragati Ishdhir	Member	Hindu College
		Dr. K.C. Singh		Sri Venkateswara College
		Dr. Pushpa Bindal		Kalindi College
		Dr. Geetanjali Sethi		St. Stephen's College
		Dr. Pradeep Kumar		Hansraj College
		Dr. N. Chandrlika		Gargi College
II	• Elements of Modern Physics (Hons. core/GE) • Quantum Mechanics and applications (Hons. Core) • Elements of Modern Physics (Prog. DSE) • Quantum Mechanics (Prog. DSE/GE) • Advanced Quantum Mechanics (Hons. DSE) • Renewable energy and Energy harvesting (SEC)	Prof. P. Das Gupta	Coordinator	Department of Physics & Astrophysics
		Dr. P.K. Jha	Convenor	Deen Dyal Upadhyaya college
		Dr. N. Santakrus Singh		Hindu College
		Dr. Punita Verma		Kalindi College
		Dr. Siddharth Lahon		Kirorimal College
		Dr. Onkar Mangla		Daulat Ram College
		Dr. Sandhya		Miranda House
		Dr. Ajay Kumar		Sri Aurobindo College

III	• Thermal Physics (Hons. Core) • Statistical Mechanics (Hons. Core) • Thermal Physics and Statistical Mechanics (Program core/GE)	Prof. S. Annapoorni	Coordinator	Department of Physics & Astrophysics
		Dr. Anuradha Gupta	Convenor	SGTB Khalsa College
		Dr. Deepak Jain	Member	Deen Dyal Upadhyaya college
		Dr. Nimmi Singh		SGTB Khalsa College
		Dr. Ashok Kumar		Ramjas College
		Dr. Aditya Saxena		Deshbandhu College
		Dr. Maya Verma		Hansraj College
IV	• Solid State Physics (Hons. Core) • Solid State Physics (Prog. DSE/GE) • Nanomaterials and Applications (DSE-Hons.+ Prog.)/GE	Prof. S. Annapoorni	Coordinator	Department of Physics & Astrophysics
		Dr. Divya Haridas	Convenor	Keshav Mahavidyalaya
		Dr. Mamta Bhatia	Member	AND College
		Dr. Rajveer Singh		ARSD College
		Dr. Shiva Upadhyaya		S.S.N. College
		Dr. Harish K. Yadav		St. Stephen's College
		Dr. Rashmi Menon		Kalindi College
		Dr. Yogesh Kumar		Deshbandhu College
V	• Mathematical Physics-I (Hons. Core) • Mathematical Physics-II (Hons. Core) • Mathematical Physics -III (Hons. Core) • Advanced Mathematical Physics (Hons. DSE) • Mathematical Physics (Program DSE/ Hons. GE) • Advanced Mathematical	Prof. T.R. Seshadri	Coordinator	Department of Physics & Astrophysics
		Dr. G.S. Chilana	Convenor	Ramjas College
		Dr. Abha Dev Habib	Member	Miranda House
		Dr. Agam Kumar Jha		Kirori Mal College
		Dr. Subhash Kumar		AND College

	Physics -II (Hons. DSE) • Computational Physics Skills (SEC) • Numerical Analysis (SEC) • Linear Algebra & Tensor Analysis (DSE)	Dr. Mamta		SGTB Khalsa College
		Dr. Neetu Aggarwal		Daulat Ram College
		Dr. Bhavna Vidhani		Hansraj College
		Dr. Ajay Mishra		Dyal Singh College
VI	• Mechanics (Hons. Core/GE) • Mechanics (Prog. Core) • Applied Dynamics (DSE/GE) • Classical Dynamics (DSE) • Physics Workshop Skills (SEC)	Prof. A. G. Vedeshwar	Coordinator	Department of Physics & Astrophysics
		Dr. Ashish Tyagi	Convenor	SSN College
		Dr. Shalini Lumb Talwar	Member	Maitreyi College
		Dr. Vandana Arora		Keshav Mahavidyalaya
		Dr. Arvind Kumar		Ramjas College
		Dr. Chitra Vaid		Bhagini Nivedita College
		Dr. Omwati Rana		Daulat Ram College
		Dr. Sunita Singh		Miranda House
		Dr. Pranav Kumar		Kirori Mal College
		Dr. Pooja Devi		Shyam lal College
VII	• Nuclear and particle Physics (Hons. DSE/GE) • Nuclear and particle physics (Prog. DSE) • Radiation Safety (SEC)	Prof. Samit Mandal	Coordinator	Department of Physics & Astrophysics
		Dr. Vandana Luthra	Convenor	Gargi College
		Dr. Namrata	Member	S.S.N. College
		Dr. Supriti Das		Gargi College
		Dr. Punit Tyagi		Ramjas College
VIII	• Astronomy and Astrophysics (DSE/GE) • Weather Forecasting (SEC)	Prof. Anjan Datta	Coordinator	Department of Physics & Astrophysics

	• Medical Physics (DSE/GE) • Atmospheric Physics (DSE/GE) • Biological Physics (DSE/GE) • Physics of Earth (DSE/GE) • Technical Drawing (SEC) • Dissertation	Dr. Jacob Cherian	Convenor	St. Stephen's College
		Dr. S.K. Dhaka	Member	Rajdhani College
		Dr. Sanjay Kumar		St. Stephen's College
		Dr. Sushil Singh		SGTB Khalsa College
		Dr. Chetna Jain		Hansraj College
		Dr. Ayushi Paliwal		Deshbandhu College
		Dr. Rekha Gupta		St. Stephen's College
IX	• Digital Systems and Applications (Hons. Core) • Embedded Systems - Introduction to Microcontroller (DSE/GE) • Digital, Analog and Instrumentation (Prog. DSE/Hons. GE) • Verilog and FPA based System design (DSE/GE) • Digital Signal Processing (DSE/GE) • Linear and Digital Integrated Circuits –E • Microprocessors and Microcontrollers –E • Electronic Instrumentation - E(DSE) • Basic Instrumentation Skills (SEC) Dissertation-E	Prof. Vinay Gupta	Coordinator	Department of Physics & Astrophysics
		Dr. Mallika Verma	Convenor	Miranda House
		Dr. Shashi Bala	Member	Ramjas College
		Dr. Arijit Chowdhuri		AND College
		Dr. Anjali Sharma		ARSD College
		Dr. Kajal Jindal		Kirori Mal College
		Dr. Poonam Jain		Sri Aurobindo College
		Dr. Savita Sharma		Kalindi College
		Dr. Alka Garg		Gargi College
X	• Analog systems and Applications (Hons. Core) • Experimental techniques	Prof. Vinay Gupta	Coordinator	Department of Physics & Astrophysics

	(DSE) • Physics of Device and Communication (DSE) • Communication System (DSE/GE) • Network Analysis and Analog Electronics-E • Communication Electronics –E • Semiconductor Devices Fabrication - E(DSE) • Photonic Devices and Power Electronics -E (DSE) • Antenna theory and wireless network -E (DSE) • Electrical circuit network skills-Prog. SEC	Dr. Monika Tomar	Convenor	Miranda House
		Dr. Sanjay Tandon	Member	Deen Dyal Upadhyaya college
		Dr. Sangeeta Sachdeva		St. Stephen's College
		Dr. Roshan		Kirorimal College
		Dr. Kuldeep Kumar		SGTB Khalsa College
		Dr. Reema Gupta		Hindu College
XI	• Practicals of all Courses	Prof. Vinay Gupta	Coordinator	Department of Physics & Astrophysics
		Dr. Sanjay Kumar	Convenor	St. Stephen's College
		Prof. P. D. Gupta	Member	Department of Physics & Astrophysics
		Prof. A.G. Vedeshwar		Department of Physics & Astrophysics
		Prof. Samit Mandal		Department of Physics & Astrophysics
		Dr. G.S. Chilana		Ramjas College
		Dr. Mallika Verma		Miranda House
		Dr. Anuradha Gupta		SGTB Khalsa College
		Dr. Monika Tomar		Miranda House

		Dr. Sangeeta D. Gadre		Kirori Mal College
		Dr. Mamta		SGTB Khalsa College
		Dr. Vandana Luthra		Gargi College
		Dr. Roshan		Kirori Mal College

ANNEXURE 1C

Final drafting team
LOCF (CBCS) Undergraduate Physics courses revision 2019
Department of Physics & Astrophysics, University of Delhi

1. Prof. Sanjay Jain
2. Prof. A. G. Vedeshwar
3. Prof. Vinay Gupta
4. Dr. Sanjay Kumar – St. Stephens' College
5. Dr. Sangeeta Gadre – Kirori Mal College
6. Dr. Punita Verma – Kalindi College
7. Dr. Rajveer Singh – ARSD College
8. Dr. Yogesh Kumar – Deshbandhu College
9. Mrs. Poonam Jain – Sri Aurobindo College
10. Dr. Ajay Kumar – Sri Aurobindo College

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

CLASSTIME Page No.
Date / /

14/12/18

A meeting of the departmental Add-on Course Committee was held on 14.12.18 at 10:35 am to discuss the details about the add on course to be proposed for coming semester in Room 207.

The following members were present:

(1) Dr Shruti Mathur — Shruti Mathur 14/12/18
(2) Ms Sunita Chhabra — Sunita Chhabra 14/12/18
(3) Ms Pooja Jain — Pooja
(4) Ms Arpita Kaul — 14/12/18
(5) Mr Ajit

The budget and syllabus for the course was finalized and it was decided to send the proposal to Principal's Office for her permission.

The course structure is designed for 36 hours (30hrs - Teaching, 3hrs - Industry interaction and 3hrs - Online & Offline Assessment).

Meeting ended at 12 pm

Sunita Chhabra 14/12/18 — 14/12/18 — Shruti Mathur 14/12/18 — Pooja

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

गणित विभाग
DEPARTMENT OF MATHEMATICS
दिल्ली विश्वविद्यालय, दिल्ली-110007
UNIVERSITY OF DELHI, DELHI – 110007
ई-मेल : head@maths.du.ac.in
दूरभाष. 27666658

PROF. C.S. LALITHA
संदर्भ संख्या: Maths/UGSyll/2018/

HEAD
दिनॉक: April 23, 2018

UG Syllabus Revision Committee under CBCS-2018

Coordinator : Hemant Singh

B.Sc. (Honours) Mathematics

1. Satish Verma, SGTB Khalsa College (Cnvener)
2. Arun Pal Singh, Dyal Singh College
3. Monika Singh, Lady Shri Ram College
4. Manjari Srivastava, Miranda House
5. Preeti Dharmraha, Hans Raj College
6. R.D. Sarma, Rajdhani College
7. Vandana Rajpal, Shivaji College
8. Anita Bakshi, Vivekananda College

B.Sc. Program and B.Sc. Mathematical Sciences

1. Ramesh Budhiraja, Sri Venkateswara College (Convener)
2. Arvind, Hansraj College
3. Raj Kumar, Kirorimal College

B.A.Programme

1. Sarla Bharadwaj, Bhim Rao Ambethkar College (Convener)
2. Anuradha Gupta, Delhi College of Arts & Commerce
3. A.R. Prasannan, Maharaja Agrasen College

GE/SEC Papers

1. Pankaj Garg, Rajdhani College (Convener)
2. Dhiraj Kumar Singh, ZHDC
3. Nidhi Arora Dhingra, Ramjas College

C.S. Lalitha

HEAD

अध्यक्ष / Head
गणित विभाग
Department of Mathematics
दिल्ली विश्वविद्यालय
University of Delhi
दिल्ली-110007 / Delhi-110007

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

---------- Forwarded message ---------
From: **head mills** <millsduhead@gmail.com>
Date: Thu, Apr 4, 2019 at 11:30 AM
Subject: UGCC Emergent Meeting
To: Elchuri Muralidhara Rao <elchurimuralidhararao@gmail.com>, Seenivasan S <svc.seenivasan.delhi@gmail.com>, Sivalingam Vivekananthan <drsviveka@gmail.com>

Dear Colleagues,

Pl attend the emergent joint meeting of the UGCC of languages (except Bengali) scheduled on **Friday, 05th April 2019 at 12 noon to finalize the first draft of the revised UG Syllabi.**

Further details in this regard will be sent by Dr. Amitava Chakraborty, the Convener of UGCC of our department.

Pl treat this very important and urgent one.

With regards,
G. Rajagopal
Head, Dept. of Modern Indian Languages
and Literary Studies, University of Delhi,
Delhi-110007

DEPARTMENT OF ENGLISH
UNIVERSITY OF DELHI
DELHI - 110007

Structure of BA Honours English
English for BA/ BCom/BSc Programme
and
English for BA(H)/BCom(H)/BSc (H)
Under Learning Outcomes-based Curriculum Framework for Undergraduate Education

Syllabus applicable for students seeking admission to the
BA Honours English, BA/BCom/BSc Programme and BA(H)/BCom(H)/BSc(H) and under LOCF
w.e.f. the academic year 2019-20

Subject to the approval of CCSPG and Academic Council

Structure of B. A. Honours English under LOCF

Core Course

Paper Titles

Sem I

1. An introduction to literary studies
2. European classical literature

Sem II

3. Indian classical literature
4. British literature 1: from medieval to the renaissance

Sem III

5. British literature 2: the seventeenth century
6. British literature 3: the eighteenth-century
7. Literature and caste

Sem IV

8. British literature 4: the romantics
9. British literature 5: the nineteenth century
10. Women's writing

Sem V

11. Twentieth century British literature
12. Forms of popular fiction

Sem VI

13. Modern European drama
14. Postcolonial literatures

Discipline Centric Elective (Any Four)

Papers 1-10 will be offered in the 5th semester and papers 11-20 will be offered in the 6th semester. Students will choose two in each semester from at least Ten to be offered by each college.

Paper titles

Semester V

1. American literature
2. Graphic narratives
3. Indian writing in English
4. Interrogating queerness
5. Literary criticism and theory– 1
6. Literature for children and young adults
7. Literature and mediality
8. Literatures of diaspora
9. Modern Indian writing in English translation
10. 19th century European realism

Semester VI

11. African literatures
12. Latin American literature
13. Literary criticism and theory – 2
14. Literature and cinema
15. Literature and disability
16. Partition literature
17. Pre-colonial Indian literatures
18. Speculative fiction and detective literature
19. Studies in modern Indian performance traditions
20. 20th century European literature

GENERIC ELECTIVE COURSE

(Any four for Honours students and any two for BA/B Com students)

List of papers

1. Academic Writing and Composition
2. Media and Communication Skills
3. Text and Performance: Indian Performance Theories and Practices (Revised)
4. Language and Linguistics
5. Readings on Indian Diversities and Literary Movements
6. Contemporary India: Women and Empowerment (Revised)
7. Language Literature and Culture (Revised)
8. Graphic narratives
9. Cinematic Adaptations of Literary Texts
10. Indian English Literature
11. Popular Fiction
12. Culture and Theory
13. Marginalities in Indian Literature
14. The Individual and Society
15. Text and Performance: Western Performance Theories and Practices
16. Literature and the Contemporary World

Papers 1-7 are papers currently being offered Some of them have been revised

Papers 8-16 are newly devised papers

AECC

Paper Title

Unit 1: Understanding the Text
Unit 2: Contextualisation and Perspectivism
Unit 3: Reception
Unit 4: Evaluation and Synthesis
Unit 5: Analysis

Skill Enhancement Course (Any Four)

Paper Titles

SEC 1- Analytical Reading and Writing
SEC 2- Literature in Social Spaces
SEC 3- Literature in Cross-Cultural Encounters (ONLY for English Honours Students)
SEC 4- Oral, Aural and Visual Rhetoric
SEC 5- Introduction to Creative Writing for Media
SEC 6- Translation Studies
SEC 7-Introduction to Theatre and Performance
SEC 8- Modes of Creative Writing: Poetry, Fiction and Drama
SEC 9- English Language Teaching
SEC 10- Film Studies
SEC 11- Applied Gender Studies: Media Studies

Detailed Syllabi

I. B. A. HONOURS ENGLISH UNDER LOCF

CORE COURSE

PAPER C1
AN INTRODUCTION TO LITERARY STUDIES
Semester 1

Course Statement

This paper offers an orientation to English literary studies for first-semester students. It focuses on formal aspects, literary terminologies, and critical concepts, introducing and formalising the critical groundwork that teachers undertake to guide students during the course of the first semester.
Unit 1 of this paper defines and critiques the category of literature, tracing the emergence of English literary studies. Units 2, 3, and 4 provide exposure to a range of literary texts, and essays on formal concepts and critical positions, familiarizing students with concepts such as close reading, form, and literary-critical approaches.
Unit 5 reflects upon the idea of literature not simply as mimetic but representational, and the relationship between historical context/material conditions and the cultural production of 'literature'.
The essays included in this course are meant to highlight issues and debates; they are not definitive or prescriptive in intent.

Course objectives

This course aims to

- develop fundamental skills and critical practices required in pursuing a course on English literatures at an Indian university in the 21st century;
- help students understand to the emergence of literary studies, textuality, and the canon;
- master the ability for close reading and critical thinking;
- initiate students to explore short literary pieces, to negotiate concepts, ideas and critical approaches to literature;
- encourage students to read texts from multiple standpoints;
- help inculcate an analytical practice that associates form with content;
- facilitate analyses of methodologies of interpretative practices; and
- enable students to interrogate their received ideas of literature and to work towards reading literature through a set of suggested practices.

Course Content

Unit 1
What is Literature?

This unit is designed to help students define/critique the category of Literature; and to understand the emergence of literary studies, textuality, and the canon. The aim is to enable students to interrogate their received ideas of literature and to work towards reading literature through a set of suggested practices. The essays listed below are meant to highlight issues and debates; they are not definitive or prescriptive in intent.

a) Peter Widdowson, Extracts from 'What is 'Literature?: Some (non)definitions' (on 'the literary', 'value', and the canon; about 12 pages), in *Literature* (London: Routledge, 1999) pp. 1-25.
b) Rita Felski, extracts from 'Conclusion' (about 3 pages), in *Uses of Literature* (John Wiley and Sons, 2011) pp. 132-35.
c) Peter Barry, 'Introduction', *Beginning Theory: An Introduction to Literary and Cultural Theory*, 2nd edition (Manchester: Manchester UP, 2002) pp. 1-38.

Unit 2
Reading Poetry

The focus of this unit is the intertwined nature of form and meaning in poetry. The skills required for a sustained interpretation of poetry involve close reading, a willingness to understand context, as well as a recognition of formal poetic technique. This unit also initiates the process of familiarising the student with critical practices, by including an essay on Class as an analytical category. This is demonstrative but not prescriptive in nature, and is meant to enable the student to explore other perspectives, read them in conjunction with other critical engagements that emerge in the classroom.

a) William Shakespeare, 'Sonnet 130', in *William Shakespeare: Complete Sonnets and Poems*, ed. Colin Burrow (New York: Oxford University Press, 2002) p. 641.
b) Phillis Wheatley, 'On Being Brought From Africa to America', in *Poems on Various Subjects, Religious and Moral* (Denver, Colorado: W.H. Lawrence & Co., 1886).
c) G. M. Muktibodh, 'So Very Far', in *Modern Indian Literatures: Poems and Short Stories* (Delhi: OUP, 1999).
d) Kaiser Haq, 'Dear Sir', in *Published in the Streets of Dhaka: Collected Poems* (Dhaka: University Press Limited, 2017) pp. 31-33.
e) Margaret Ferguson, Mary Jo Salter and Jon Stallworthy, 'Versification and Poetic Syntax', in *The Norton Anthology of Poetry*, 5th edition (New York and London: W.W. Norton & Company, 2005) pp. 2021-65.
f) J. A. Cuddon, (i) 'Lyric'; (ii) 'Sonnet', in *The Penguin Dictionary of Literary*

Terms and Literary Theory, 4th edition (1999) pp. 481-84; 843-47.

g) M. H. A. Abrams, ‘Irony’, in *A Glossary of Literary Terms*, 7th edition (1999) pp. 134-38.

h) Gary Day, ‘Introduction’, in *Class*, New Critical Idiom (Routledge, 2001) pp. 1-18.

Unit 3

Reading Prose

The focus of this unit is to expose the student to varied nuances of narrative and formal aspects of prose. The skills required for a sustained interpretation of prose involve close reading, deciphering aspects of narrative like focalisation, voice, tonality, style, etc. This unit also includes an essay on disability, a perspective to both allow an understanding of the figurative device (its function as a literary technique) as well as the ways in which representation works to signify culture.

a) H. G. Wells, ‘The Country of the Blind’, in *The Country of the Blind and Other Science Fiction Stories*, ed. Martin Gardner (New York: Dover, 1997) pp. 1-30.

b) Rabindranath Tagore, ‘Subha’, trans. Mohammad A. Quayum, in *Rabindranath Tagore: The Ruined Nest and Other Stories* (Kuala Lumpur: Silverfish, 2014) pp. 43-50.

c) Kumud Pawde, ‘The Story of My Sanskrit’, trans. Priya Adarkar, in *The Exercise of Freedom: An Introduction to Dalit Writing*, eds K Satyanarayana and Susie Tharu (New Delhi: Navayana Publications, 2013) pp. 71-83.

d) Gerald J. Prince, from *Narratology: Form and Function of the Narrative* (New York: Mouton Publishers, 1982) pp. 7-16 and 103-15.

e) Chris Baldick, (i) ‘Plot’; (ii) ‘Focalization’, in *The Concise Oxford Dictionary of Literary Terms*, 2nd edition (2001) pp. 195-6; 98.

f) Clare Barker and Stuart Murray, eds, ‘Introduction: On Reading Disability in Literature’, in *The Cambridge Companion on Literature and Disability* (New York: Cambridge University Press, 2017) pp. 1-13.

Unit 4

Reading Drama

This unit introduces the students to the form of drama as a crucial literary genre, one which goes beyond the act of reading and focuses on performance. The play *Halfway House* by Mohan Rakesh negotiates the idea of the public and private space and works on the contested notions of domesticity. The essay by Lizbeth Goodman on gender, and the expository piece on theatre by Watson are meant to introduce the conceptual and performative aspects of drama to the students.

a) Mohan Rakesh, *Halfway House*, trans. Bindu Batra, ed. Dilip K Basu (Worldview: Delhi, 2011).

b) G. J. Watson, 'The Nature of Drama', in *Drama: An Introduction* (London: Macmillan, 1983)
pp. 1-18.
c) Lizbeth Goodman, ed., *Literature and Gender*, extracts (about 21 pages) (NY: Routledge,1996) pp. 1-40.

Unit 5
Readings: Issues in Literature, Culture and Criticism

This unit focuses on contesting and demystifying pre-conceived notions of literature as mimetic representations. It aims to underline literature as part of cultural production, firmly embedded in historical specificity. The essay by Mitchell is an expository piece on the idea of literature as representation beyond mimesis. The piece by Eagleton aims to expose students to the idea of political criticism, i.e., examining literature through diverse political perspectives of caste, race, class, gender, culture, disability, etc. The essay by Raymond Williams introduces a crucial keyword, 'culture', to demonstrate the embeddedness of literature within cultural history. Catherine Belsey's essay underlines the praxis between readings and textuality and also introduces students to the act of writing.

a) W. J. T. Mitchell, 'Representation', in *Critical Terms for Literary Study*, eds Frank Lentricchia and Thomas McLaughin (Chicago: University of Chicago Press, 1990) pp. 11-22.
b) Raymond Williams, 'Culture', in *Keywords: A Vocabulary of Culture and Society* (New York: OUP, 1983 rpt) pp. 87-93.
c) Terry Eagleton, extracts from 'Conclusion: Political Criticism', in *Literary Theory: An Introduction* (on literature, criticism, and ideology; approximately 16 pages) (New Jersey: Blackwell, 2000 rpt) pp. 169-208.
d) Catherine Belsey, 'Textual Analysis as a Research Method', in *Research Methods for English Studies*, ed. Gabriel Griffin (Edinburgh: Edinburgh University Press, 2013) pp. 157-74

Teaching Plan
Paper C1: An Introduction to Literary Studies

Week 1 – Introduction to the discipline of Literary Studies, contexts, methods
Week 2 – Unit 1:
(a) Widdowson, 'What is 'Literature?''
(b) Felski, from *The Uses ofLiterature*

Week 3 – Unit 1 (contd):
(c) Barry, 'Introduction', *Beginning Theory*
Week 4 – Unit 2:
(a) Shakespeare, 'Sonnet 130'
(b) Wheatley, 'On Being Brought from Africa to America'

Week 5 – Unit 2 (contd):
(c) Muktibodh, ‘So Very Far’; Haq, ‘Dear Sir’
Week 6 – Unit 2 (contd)
(e) Ferguson, Salter and Stallworthy, ‘Versification and Poetic Syntax’;
(f) Cuddon, ‘Lyric’, ‘Sonnet’;
(g) Abrams, ‘Irony’;
(h) Day, 'Introduction' in *Class*
Week 7 -- Unit 3
(a) Wells, ‘The Country of the Blind’;
(b) Tagore, ‘Subha’;
(c) Pawde, ‘The Story of My Sanskrit’
Week 8 --Unit 3 (contd):
(d) Prince, from *Narratology*;
(e) Baldick, ‘Plot’, ‘Focalization’
(f) Barker and Murray ‘Introduction: On Reading Disability in Literature’;
Week 9 -- Unit 4
(a) Rakesh, *Halfway House.*
Week 10 – Rakesh (contd)
Week 11 -- Unit 4 (contd)
(b) Watson, ‘The Nature of Drama';
(c) Goodman, ed. *Literature and Gender*
Week 12 -- Unit 5
(a) Mitchell, ‘Representation’;
(b) Williams, ‘Culture’;
(c) Eagleton, ‘Political Criticism’
Week 13 -- Unit 5 (contd)
(d) Belsey, ‘Textual Analysis as a Research Method’
Week 14 -- Concluding lectures, preparation for the written examination etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments

3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Orientation Literary Studies Text
Close reading Critical thinking Interpretation Representation Critical perspective
Genre
Poetry
Prose
Drama

Sub-committee

Mudita Mohile, Gargi College (Coordinator)
Jenny Rowena, Miranda House
Karuna Rajeev, LSR College
Nabanita Chakraborty, Hans Raj College
Sachin N., Dyal Singh College
Someshwar Sati, Kirori Mal College

PAPER C2
EUROPEAN CLASSICAL LITERATURE
Semester 1

Course Statement

This course provides a humanist foundation to English studies, to be considered essential reading. It enables an exploration of classical Greek, Roman, and Hebrew literature in English translation, tracing its impact and influence on English literature from the period of the Renaissance to the Modern. The paper offers a wide-ranging perspective on the aesthetic, philosophical, and social concerns of classical literature. It introduces students to multiple genres and forms, including the epic, tragedy, comedy, the lyric, and the dialogue. Selections from the Old and New Testament of The Bible provide the context to literary styles and ideas governing Western literature's interface with the community and its spiritual needs.

Course Objectives

This course aims to

- explore the historical, cultural, and philosophical origins of tragedy and comedy;
- engage with both genres in their distinctive form, style, and characterization, including their representation of human aspirations, foibles, grandeur, and vulnerability;
- examine representations of disability in mythology through the reading of selections from Ovid and in the only extant form of a Satyr play, Cyclops by Euripides;
- examine the Book of Job from the Old Testament of The Bible for its literary style, including its debate over tragic fate and human suffering, and to locate its enduring influence over subsequent humanist writings;
- juxtapose the Old Testament to ideas of compassion and surrender to God's will as outlined in the selection from the New Testament;
- study the history of ideas pertaining to the human-social-divine interface in theorisations on form, narrative, social organization, and aesthetics in the writings of Plato, Aristotle, and Horace; and
- study gendered explorations of human relations in classical literature in multiple genres, and to examine a woman writer's standpoint on love, war and the primacy of the gendered self.

Course Content

Unit 1
a) Homer, *The Odyssey*, trans. Robert Fagles (Penguin Classics, 1996).

Unit 2

a) Sophocles, 'Antigone', trans. Robert Fagles, in *The Three Theban Plays*, revised reprint (Penguin Classics, 1984).
b) Aristotle, From *Poetics*, Chapters 6, 23, 26 (Penguin Classics, 1996).

Unit 3

a) Plautus, *The Brothers Menaechmus*, trans. E.R. Walting (Penguin Classics, 1965).
b) Ovid, Selections from *Metamorphoses*, 'Philomela' (from Book 9), 'Tiresias' (fromBook 3)

Unit 4

a) 'The Book of Job', The Holy Bible, The New International Version (Zondervan, 2011).
b) Selection from 'The Gospel According to Matthew', Chapter 5,Verse1-48 (Sermon on the Mount).

Unit 5

a) Plato, (i) ‘The Simile of the Cave’; (ii) ‘Theory of Art’; both in *Republic*, Book 10 (Penguin Classics, 2007) pp. 240-48; 335-53.
b) Sappho, (i) ‘On the Throne of Many Hues, Immortal Aphrodite’; (ii) ‘Some Say an Army of Horsemen’, from Lyrics 1, trans. Diane J. Rayor and Andre Lardinois, in *A New Translation of Complete Works*, (2014).
c) Euripides, *Cyclops*, trans. Heather McHugh (OUP, 2001), pp. 36-67.
d) Horace ‘Ars Poetica’, trans. H. Rushton Fairclough (Harvard University Press, 1929).

Teaching Plan
Paper C2: European Classical Literature

Week 1 – Introduction to European Classical Literature; Unit 1 -- Homer, *Odyssey*
Week 2 – Homer (contd)
Week 3 – Unit 2 -- Aristotle, *Poetics*; Sophocles, *Antigone*
Week 4 – Sophocles (contd)
Week 5 – Unit 3 -- Discussion: Old Comedy, Roman Comedy; Plautus, *Brothers Menaechmus*
Week 6 – Plautus (contd)
Week 7 – Unit 3 -- Ovid, prescribed selections
Week 8 – Unit 5 -- Horace, ‘Ars Poetica’
Week 9 – Unit 5 -- Sappho, prescribed selections; Euripides, *Cyclops*
Week 10 – Unit 5 -- Plato, prescribed selections
Week 11 – Unit 4 -- The Bible, *Book of Job*
Week 12 – *Book of Job* (contd)
Week 13 – Unit 4 -- The Bible, *The Gospel according to Matthew*, prescribed sections
Week 14 – Critical discussion of texts, discussion of question paper, examination related queries from students, revision.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments

3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Epic
Tragedy
Comedy
Satire
Lyric
Myth
Dialogue
Bible
Poetics
War
Heroism

Sub-committee

Rina Ramdev, Sri Venkateshwara College (Coordinator)
B. Mangalam, Aryabhatta College
Mudita Mohile, Gargi College
N. A. Jacob, Ramjas College
Rudrashish Chakraborty, Kirorimal College
Someshwar Sati, Kirorimal College

PAPER C3
INDIAN CLASSICAL LITERATURE
Semester 2

Course Statement

The paper introduces students to a rich and diverse literature from two classical languages of India, Sanskrit and Tamil. A key feature is the study of the poetics in the epics of both languages, including their literary traditionsand their representations of a pluralist society in terms of linguistic, religious, and generic diversity. The paper lays a foundation in Indian poetics, theories of representation, aesthetics,aspects of Indian theatre, and traditions of story-telling and narrative structures. Optional papers on

Indian literature in subsequent semesters will reinforce the centrality of this paper in providing an understanding of key concepts related to the form and content of Indian literatures.

Course Objectives

The course aims to

- study significant sections of Vyasa's Mahabharata in order to determine conceptualisation and representation of class, caste, gender, and disability in the context of the epic battle over rights and righteousness;
- examine selections from Ilango's *Cilapattikaram* to understand the interplay of Tamil poetics and the lifestyle of communities, negotiating ideas related to love, justice, war, governance, and conduct in private and public domains;
- study Sanskrit drama, a Nataka, and a Prakarna, to appreciate its debts to Natyashastra in their formal aspects;
- explore the central concerns of Sanskrit drama in relation to notions of the ideal ruler, lover, friend, and spouse; the presence of Buddhist edicts,thevoices of the poor and the marginalised, the position of women in different social strata, the subversive use of humour, and the performative aspects of Sanskrit theatre;
- introduce students to selections elucidating Tamil and Sanskrit poetics (Unit 5); a critical overview of the theorisation of Akam, Puram, and Thinai in Tolkappiyam, juxtaposed to lyrics from Sangam poetry; the Rasa theory from Natyashastra, to help students appreciate the inter-connections between theory and practice in theatre; a representation of disability in theatre, examined through the portrayal of Vidushaka; and
- examine ideas of multiple and counter narratives/versions of epics, through a critical reading of Chandrabati's Ramayana foregrounding a woman's/Sita's perspective.

Course Content

Unit 1

Vyasa, selections from The Mahabharata, from *The Mahabharata of Krishna-Dwaipayana Vyasa*, trans. K. M. Ganguli (Delhi: Munshiram Manoharlal Publishers, 2012).

a) ‘The Dicing’, Book 2, Sabha Parva Section XLVI-LXXII.
b) ‘The Temptation Of Karna’, Book 5, Udyog Parva, Section CXL-CXLVI.
c) ‘Drona and Ekalavya’, Book 1, Adi Parva, Section CXXXIV-CXXXV.
d) ‘Dhritrashtra and Gandhari’s Wrath’, Book 11, Section XI-XV.

Unit 2

Kalidasa, ‘Abhijnanasakuntalam’, trans. Chandra Rajan,in*Kalidasa: The Loom of Time*, reprint 2000, Appendix III (Penguin Classics, 1989) pp. 320-21.

Unit 3

Sudraka, *The Mrichchhakatika of Sudraka*, trans. M. R. Kale (Delhi: Motilal Banarsidas Publishers, 1924, reprint 2013).

Unit 4

Ilango Atikal, *The Cilappatikaram*,Cantos 1, 2, 7, 18, 19, 20, 21, 22, 24, 26, 30, trans. R. Parthasarathy (Coloumbia University Press, 1993; Penguin Books India, 2004).

Unit 5

a) A. R. Venkatachalapathy, 'Introduction', in *Love Stands Alone: Selections from Tamil Sangam Poetry* (Delhi: Penguin Classics, 2013) pp. XIII-XLI, 25, 45, 70, 186.
b) Selections from *Natyasastra*, (i) Chapter 6, 'The Sentiments'; (ii) Chapter 20, 'Ten Kinds of Play'; (iii) Chapter 35, 'Characteristics of the Jester', trans. Manomohan Ghosh (Calcutta: Asiatic Society of Bengal, 1951) pp.105-17; 355-74; 548-50.
c) Nabaneeta Deb Sen, 'A Woman's Retelling of the Rama Tale: Narrative Strategies Employed in the Chandrabati Ramayana', in *Narrative: A Seminar*, ed. Amiya Dev (New Delhi: Sahitya Akademi, 1994), pp. 170-79.

Teaching Plan
Paper C3: Indian Classical Literature

Week1 – Introduction to Indian Classical Literature
Week 2 – Unit 1 – The Mahabharata: Drona and Ekalavya; Dhritrashtra and Gandhari's wrath
Week 3 – The Mahabharata (contd): The Dicing; The Temptation of Karna
Week 4 – Unit 5 --*Natyashastra*, prescribed sections
Week 5 – Unit 2 -- Kalidasa, *Abhijnasakuntalam* and Appendix 3
Week 6 – Kalidasa (contd)
Week7 – Unit 3 -- Sudraka, *Mrichchakatika*
Week 8 – Sudraka (contd)
Week 9 – Unit 5 -- Venkatachalapathy, 'Introduction', in *Love Stands Alone: Selections from Tamil Sangam Poetry*
Week 10 – Unit 4 -- Introduction to Atikal, *Cilappatikaram*, Cantos1, 2, 7, 18, 19
Week11 – Atikal (contd), Cantos 20, 21, 22, 24, 26, 30
Week12 – Unit 5 -- Deb Sen, 'A Woman's Retelling of the Rama Tale'
Week 13 – Sanskrit plays revisited; critical discussion on the prescribed plays
Week 14 – Indian epics revisited; critical discussion on Mahabharata and *Cilappatikaram*

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Indian Epics
Natyashastra
Akam Puram
Rasa

Sub-committee

B. Mangalam, Aryabhatta College (Coordinator)
Dhananjay Kapse, Kirorimal College
Karuna Rajeev, Lady Sri Ram College
Mudita Mohile, Gargi College
Sheuli Chowdhury, Gargi College
Someshwar Sati, Kirorimal College

PAPER C4
BRITISH LITERATURE 1: FROM MEDIEVAL TO RENAISSANCE
Semester 2

Course Statement

This paper is the first Core British literature paper out of a cluster of six, and initiates the student into the earliest writings in England from medieval literature through the Renaissance. The first section of this first paper on British literature begins with a short lyric in the female voice, introducing Anglo-Saxon writing in modern English. Chaucer's 'General Prologue', which is taught in Middle English, introduces students to*The Canterbury Tales* and helps them recognize its narrative complexity and structure. Two plays, *Much Ado About Nothing* as representative of Shakespeare's comedies, and Marlowe's *Dr. Faustus* as a dramatization of debates on Renaissance man, enable a focus on drama as a significant genre in the Renaissance. The prose readings establish the European context for the Renaissance and offer readings crucial to understanding the cultural and religious aspects of the age.

Course Objectives

This course aims to

- introduce students to the tradition of English Literature from its beginnings;
- cover the medieval and Renaissance literary periods from the earliest Anglo-Saxon narratives to key Renaissance writers and texts, within their historical and intellectual contexts; and
- offer, through Montaigne's essay included here (on conjoined twins), a perspective on the history of ideas about disabilities and its varied meanings in a historical context.

Course Content

Unit 1

a) Anon., 'The Wife's Lament' (1072 AD), Anglo-Saxon lyric from *The Exeter Book*, in*The Norton Anthology of English Literature*, Vol. 1, 8th edn., p. 114.
b) Geoffrey Chaucer, 'General Prologue', (in Middle English), from *The Canterbury Tales*, The Riverside Chaucer, ed. Larry D. Benson (Boston: Houghton Mifflin, 2000).

Unit 2

a) Thomas Wyatt, (i) 'Whoso List to Hunt'; (ii) 'They Flee from Me'

b) Philip Sidney, (i) 'Loving and Truth'; (ii) 'Not at First Sight'.
c) Edmund Spenser, (i) Sonnet LVII 'Sweet warrior'; (ii) Sonnet LXXV 'One day I wrote her name', both from 'Amoretti'.
d) Isabella Whitney, 'I. W. To Her Unconstant Lover'.

Unit 3
Christopher Marlowe, *Dr. Faustus.*

Unit 4
William Shakespeare, *Much Ado About Nothing.*

Unit 5
Readings

a) Pico Della Mirandola, excerpts from the *Oration on the Dignity of Man* (1486), in*The Portable Renaissance Reader*, eds James Bruce Ross and Mary Martin McLaughlin (New York: Penguin Books, 1953) pp. 476–9.
b) Desiderius Erasmus, *In Praise of Folly* (1511), trans. Hoyt Hopewell Hudson (Princeton University Press: 2015) pp. 139-155.
c) Niccolo Machiavelli, *The Prince* (1513), Chaps. 15, 16, 18, and 25, ed. and trans. Robert M. Adams (New York: Norton, 1992).
d) John Calvin, 'Predestination and Free Will', from *Institutes of the Christian Religion* (1536), in *The Portable Renaissance Reader*, ed. James Bruce Ross and Mary Martin McLaughlin (New York: Penguin Books, 1953) pp. 704–11.
e) Michel de Montaigne, 'Of a Monstrous Child' (1580), from *Essays.*

*Suggested editions are recommended but not compulsory; any scholarly edition may be used.
Suggested alternative editions for *The Canterbury Tales*:

- *The Riverside Chaucer*, ed. Larry D. Benson (OUP, 2008).
- *The Canterbury Tales*, eds Robert Boenig and Andrew Taylor (Peterborough: Broadview Press, 2012).
- *The Canterbury Tales* (Middle English), ed. Jill Mann (Penguin Classics, 2005).
- *The Canterbury Tales: Seventeen Tales and The General Prologue,* Norton Critical Editions, eds V. A. Kolve & Glending Olson.

Teaching Plan
Paper C4: British Literature 1 – From Medieval to Renaissance

Week 1 -- Introduction to early and late medieval literature; Anon., 'The Wife's Lament' (1072 AD), the Anglo-Saxon lyric
Week 2 -- 'The Wife's Lament' (contd); Chaucer, 'General Prologue'

Week 3 – Chaucer (contd)
Week 4 – Chaucer (contd)
Week 5 – Poetry:

(a) Wyatt, (i) 'Whoso List to Hunt'; (ii) 'They Flee from Me'

(b) Sidney, (i) 'Loving and Truth'; (ii) 'Not at First Sight'.

(c) Spenser, (i) Sonnet LVII 'Sweet warrior'; (ii) Sonnet LXXV 'One day I wrote her name'

(d) Whitney, 'I. W. To Her Unconstant Lover'.

Week 6 -- Poetry (contd)
Week 7 – Marlowe, *Dr. Faustus*
Week 8 – Marlowe (contd)
Week 9 – Marlowe (contd); Introduction to Shakespeare
Week 10 – Shakespeare, *Much Ado About Nothing*
Week 11 – Shakespeare (contd)
Week 12 – Readings:

(a) Mirandola, excerpts from the *Oration on the Dignity of Man*

(b) Erasmus, *In Praise of Folly*

Week 13 – Readings:
(c) Machiavelli, *The Prince*, Chaps. 15, 16, 18, and 25
(d) John Calvin, 'Predestination and Free Will'
Week 14 – Montaigne, 'Of a Monstrous Child; Conclusions and Questions

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords
Feudalism
Ecclesiastical order
Love and marriage
Courtly love tradition
Petrarchan influence
Renaissance humanism
Elizabethan world picture
Mystery and Morality plays
Greco-Roman classical tradition
Comedy and Tragedy

Sub-committee

Nabanita Chakraborty, Hansraj College (Coordinator)
Madhvi Zutshi, S. G. T. B. Khalsa College
Namita Sethi, Janki Devi Memorial College
Rudrashish Chakraborty, Kirorimal College
Sherina Joshi, Deshbandhu College
Shyista Khan, Dyal Singh College

Additional consultation for disability perspectives: Someshwar Sati, Kirori Mal College and Karuna Rajeev, Lady Sri Ram College

PAPER C5
BRITISH LITERATURE 2: THE SEVENTEENTH CENTURY
Semester 3

Course Statement

The paper begins with the Jacobean period through Shakespeare's tragedy *Macbeth*, representing one of his finest Jacobean tragedies on issues of succession and individualism pertinent to the age. Milton's *Areopagitica* is an early defence of free speech and works well to place debates on free will at the time. Milton's significant portrayal of Satan in Book 1 of *Paradise Lost* has influenced imaginative writing on the idea of evil thereafter. In addition to the two metaphysical poets, Donne and Marvell, the poetry unit extends through the Restoration with Rochester, whose depiction of the libertine figure and his ideas on political and sexual sovereignty are central to understanding Restoration drama. Aemilia Lanyer was the first secular woman poet to be published professionally and the section from her poem offers a counter view on Eve. Aphra Behn, currently one of the most popularly studied writers of the Restoration, offers an opportunity to discuss the paradox of Tory feminists amongst other issues on Royalism and libertinism. The readings enable a wide philosophical and political understanding of the period.

Course Objectives

This course aims to

- help students explore poetry, drama and prose texts in a range of political, philosophical and cultural material from the end of the Renaissance through the English Civil War and Restoration in the seventeenth century;
- examine the turmoil about succession and questions on monarchy as they lead up to the civil war, both in drama like Shakespeare and Behn as well as in the poetry Milton;
- show a new interweaving of the sacred and the secular subjects of poetry, in metaphysical poetry and other poets like Lanyer;
- study Bacon's essay on deformity through the lens of disability and its definitions, linked back to Montaigne in the earlier paper;
- analyseCartesian dualism that provides a basis for reading ideas of body and mind in the period and after;
- exploreHobbes's views on materialism and the equality of men, as they are interestingly juxtaposed with his argument for a strong state and his view of man as selfish by nature;
- show how Winstanley's writing, on the other hand, brings together Christianity and communality in a radical argument for equality after the civil war; and
- explore the newness of this century in Cavendish's bold exploration of natural philosophy or science as a domain for women

Course Content

Unit 1

William Shakespeare, *Macbeth.*

Unit 2

a) John Donne, (i) 'The Canonization'; (ii) 'Batter My Heart'; (iii) 'Valediction: Forbidding Mourning'
b) Andrew Marvell, 'To His Coy Mistress', in *The Norton Anthology of English Literature*, Vol. 1, 8th edition, ed. Greenblatt et al., p. 1703.
c) Aemilia Lanyer, 'Eve's Apology in Defense of Women', section from *Salve Deus Rex Judaeorum* (1611), in *The Norton Anthology of English Literature*, 8th edition, ed. Greenblatt et al., Vol. 1, pp. 1317-19.
d) John Dryden, 'Heroic Stanzas on the Death of Oliver Cromwell (1659), in *John Dryden: The Major Works*, ed. Keith Walker (Oxford: OUP, 1997) pp. 1-6.
e) John Wilmot, Earl of Rochester, 'The Imperfect Enjoyment' (1680), in *The Norton Anthology of English Literature*, Vol. 1, 8th edition, ed. Greenblatt et al., pp. 2169-71.

Unit 3

John Milton

a) *Areopagitica* (1644), excerpts, in *The Norton Anthology of English Literature*, Vol. 1, 8th edition, ed. Stephen Greenblatt et al., pp. 1816-25.
b) *Paradise Lost* (1667) Book 1, in *John Milton: Paradise Lost*, Longman Annotated English Poets, 1998.

Unit 4

Aphra Behn, *The Rover* (1677), in *Aphra Behn:* The Rover *and other Plays*, ed. Jane Spencer (Oxford: OUP, 2008).

Unit 5
Readings

a) Francis Bacon, (i) 'Of Truth'; (ii) 'Of Deformity'; both in *Essays* (1597).
b) René Descartes, excerpts from 'Discourse on Method' (1637) Part 4, in *Discourse on Method and Meditations on First Philosophy*, trans. Donald A. Cress, (Indianapolis: Hackett, 1998) pp. 18-19.
c) Thomas Hobbes, selections from *The Leviathan* (1651): title page, Introduction, Chaps 1 and 13 from Part I, 'Of Man', ed. Richard Tuck (Cambridge University Press, 1996).
d) Gerrard Winstanley, from 'A New Year's Gift Sent to the Parliament and Army' (1650), in *The Norton Anthology of English Literature*, Vol. 1, 8th edition, ed. Greenblatt et al., pp. 1752-57.
e) Margaret Cavendish, excerpts from 'The Blazing World' (1666), in *The Norton Anthology of English Literature*, Vol. 1, 8th edition, ed. Greenblatt et al., pp. 1780-85.

*Suggested editions are recommended but not compulsory - any scholarly edition may be used.
Suggested editions for Milton's *Paradise Lost:*

- John Milton, *Paradise Lost*, Books 1 & 2, Oxford Student Texts, ed. Anna Baldwin (OUP India, 2009).
- John Milton, *Paradise Lost*, Modern Library Classics, eds. William Kerrigan, John Rumrich, Stephen M. Fallon (Modern Library, 2008).
- John Milton, *Paradise Lost*, eds Stephen Orgel and Jonathan Goldberg (Oxford World's Classics, 2008).

Suggested editions for Aphra Behn's *The Rover*:

- Aphra Behn, *Oroonoko, The Rover and Other Works*, ed. Janet Todd (Penguin, 1993).
- Aphra Behn, *The Rover*, ed. Robyn Bolam, 3rd edition (Methuen Drama, 2012).
- Aphra Behn, 'The Rover', in *Restoration and Eighteenth-Century Comedy*, ed. Scott McMillin, Norton Critical Editions, Second Edition.

Teaching Plan
Paper C5: British Literature 2 – The Seventeenth Century

Week 1 -- Introduction to the Jacobean period, the Civil War, and the Restoration: period, genres, and themes; Unit 1 – Shakespeare, *Macbeth*
Week 2 – Shakespeare (contd)
Week 3 -- Shakespeare (contd)
Week 4 – Poetry:
(a) Donne, (i) 'The Canonization'; (ii) 'Batter My Heart'; (iii) 'Valediction: Forbidding Mourning'
(b) Marvell, 'To His Coy Mistress'
(c) Lanyer, 'Eve's Apology in Defense of Women', section from *Salve Deus Rex Judaeorum*
(d) Dryden, 'Heroic Stanzas on the Death of Oliver Cromwell'
(e) Rochester, 'The Imperfect Enjoyment'
Week 5 -- Poetry (contd)
Week 6 -- Poetry (contd); Milton, *Areopagitica*
Week 7 – Milton, *Paradise Lost*, Book 1
Week 8 -- *Paradise Lost* (contd)
Week 9 -- *Paradise Lost* (contd)
Week 10 – Behn, *The Rover*
Week 11 – Behn (contd)
Week 12 – Behn (contd)
Week 13 – Readings:
(a) Bacon, (i) 'Of Truth'; (ii) 'Of Deformity'
(b) Descartes, excerpts from 'Discourse on Method'
(c) Hobbes, selections from *The Leviathan*,title page, Introduction, Chaps 1 and 13 from Part I, 'Of Man'
(d) Winstanley, from 'A New Year's Gift Sent to the Parliament and Army'
(e) Cavendish, excerpts from 'The Blazing World'
Week 14 -- Readings (contd); Conclusions and Questions

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Secular thought
Skepticism
Jacobian Drama
The rise of Puritanism
Metaphysical conceits
Individualism and free-will
Cartesian dualism
Restoration
Libertinism, satire

Sub-committee

Rudrashish Chakraborty, Kirori Mal College (Coordinator)
Madhvi Zutshi, S.G.T.B. Khalsa College
Nabaneeta Chakraborty, Hansraj College
Namita Sethi, Janki Devi College
Sherina Joshi, Deshbandhu College
Shyista Khan, Dyal Singh College

PAPER C6

BRITISH LITERATURE 3: THE EIGHTEENTH CENTURY

Semester 3

Course statement

This is a survey course covering a variety of genres in eighteenth-century England, including both canonical and newer material within a history of ideas. It is designed to represent a comprehensive study of texts both in the Augustan period and in the later eighteenth century, often called the age of sensibility. The course includes the major canonical authors of the early eighteenth century—Swift, Pope, and Johnson—with some of their representative texts, as well as writers who have received considerable recent scholarship like Daniel Defoe, Eliza Haywood, and Lady Montagu. The latter half of the century is marked by the emerging genre of the novel and Fielding's first novel *Joseph Andrews*, considered by many to be one of the earliest English novels. The paper includes non-fictional genres that were dominant in the period like the periodical essay and the public letter. The intellectual context includes Locke whose treatise marked empiricism, and Shaftesbury's moral philosophy, as philosophical writings in this period were not so distinct from the literary and reached a wider audience. An excerpt from one of the earliest slave autobiographies at the end of the century helps to contextualize Britain in a global world and the debates on the abolition of the slave trade.

Course Objectives

The course aims to

- examine Pope's craftsmanship in verse, as well as his complex rendering of the mock-epic;
- show, through the shift to a somber mood in Gray but also through a continued association with classical poetry, the continuities and contrasts from the age of satire to age of sensibility;
- raise questions about satire as a mode, as well as look at questions of genre, through Swift's satiric narrative within the mode of fictional travel writing;
- study Fielding's first novel as providing a brilliant example of the amalgamation of previous genres which made the new genre of the novel, and to look at his indebtedness to Richardson despite the overt satire on *Pamela*;
- examine the eighteenth century as a great period for non-fictional forms of writing, drawing attention to the ways in which the periodical essay, for instance, sought to be like philosophy, just as Locke's treatise sought to be like a popular essay, thus pointing out the play with genre in these texts; and
- encourage an extended discussion on the meanings of disability in the early modern period through the Enlightenment, through William Hay's piece on deformity, a response to Bacon.

Course Content

Unit 1

a) Alexander Pope, *Rape of the Lock*.
b) Thomas Gray, *Elegy Written Upon a Country Churchyard*.

Unit 2

Jonathan Swift, *Gulliver's Travels* (1726).

Unit 3

Henry Fielding, *Joseph Andrews* (1742)

Unit 4
Periodical Essays, Biographies, and Letters

a) Addison and Steele, (i) Addison, Essay No. 10, Monday, March 12, 1711; (ii) Addison, Essay No. 69, on the stock-exchange, Saturday, May 19, 1711, both from *The Spectator* (1711-12).
b) Lady Mary Wortley Montague, (i) 'The Turkish Method of Inoculation for the Small Pox'; (ii) 'The Ladys Coffeehouse'; both from *The Turkish Embassy Letters* (1716-18, pub. 1763); or the Turkish Baths excerpts in https://www.wwnorton.com/college/english/nael/18century/topic_4/montagu.htm
c) Daniel Defoe, (i) Letter XXII, 'The Complete English Tradesman' (1726); (ii) Letter IV, 'The Great Law of Subordination Considered'; (iii) 'The Complete English Gentleman'; all three in *Literature and Social Order in Eighteenth-Century England*, ed. Stephen Copley (London: Croom Helm, 1984).
d) Eliza Haywood, Selections from *The Female Spectator* (1744-46), ed. Patricia Meyer Spacks, pp.7-23.
e) Samuel Johnson, (i) Essay No. 4, on the novel, in 'The Rambler' (1750); (ii) 'Pope's Intellectual Character: Pope and Dryden Compared', excerpt from 'The Life of Pope' (1781); both in *The Norton Anthology of English Literature*, Vol.1, ed. Stephen Greenblatt, 8th edn (New York: Norton, 2006) pp. 2693–94; 2774–77.

Unit 5
Readings

a) John Locke, 'Of Ideas in general, and their Original', Paragraphs 1-8, from *An Essay concerning Human Understanding* (1689), Chap 1 Book II,ed. John Nidditch(Oxford: Clarendon Press, 1975) pp. 104-108.

b) Anthony Ashley Cooper, Earl of Shaftesbury, excerpts from 'Inquiry concerning Virtue or Merit' (1711) Book I, Part II, Section 3 and Book II, Part I, Section 1, in *Characteristics of Men, Manners, Opinions, Times*, ed. Lawrence E. Klein (Cambridge: Cambridge University Press, 1999) pp. 172-73, 175, 192-93.

c) William Hay, from *Deformity: An Essay* (1754) (London: R and J. Dodsley, 1756) pp. 1-11, 44-51.

d) Adam Smith, from *The Wealth of Nations* (1776), ed. Edwin A. Seligman (London: J. M. Dent, 1901), pp. 12-15, 400-401, 436-37.

e) Olaudah Equiano, 'The Middle Passage', excerpt from Chapter Two in *The Interesting Narrative of the Life of Olaudah Equiano; or, Gustavus Vassa, the African, Written by Himself* (1789), ed. Robert J. Allison (Boston, 1995), pp. 54–8.

Teaching Plan

Paper C6: British Literature 3 – The Eighteenth Century

Week 1 -- Introduction to the long eighteenth century; Unit 1 -- Pope, *Rape of the Lock*

Week 2 -- Pope (contd)

Week 3 -- Pope (contd)

Week 4 -- Unit 1 (contd): Gray, *Elegy Written upon a Country Churchyard*; Unit 2 -- Swift, *Gulliver's Travels*

Week 5 -- Swift (contd)

Week 6 -- Swift (contd)

Week 7 -- Swift (contd); Unit 3 -- Fielding, *Joseph Andrews*

Week 8 -Fielding (contd)

Week 9 - Fielding (contd)

Week 10 - Unit 4 -- Prose genres:

(a) Addison and Steele, (i) Addison, Essay No. 10, Monday, March 12, 1711; (ii) Addison, Essay No. 69, on the stock-exchange

Week 11 - Prose genres (contd):

(b) Lady Montague, (i) 'The Turkish Method of Inoculation for the Small Pox'; (ii) 'The Lady's Coffeehouse'

(c) Defoe, (i) Letter XXII, 'The Complete English Tradesman' (1726); (ii) Letter IV, 'The Great Law of Subordination Considered'; 'The Complete English Gentleman'

Week 12 - Prose genres (contd):

(d) Haywood, Selections from *The Female Spectator*

(e) Samuel Johnson, (i) Essay No. 4, on the novel, in 'The Rambler' (1750); (ii) 'Pope's Intellectual Character: Pope and Dryden Compared', excerpt from 'The Life of Pope'

Week 13 - Unit 5 -- Readings:

(a) Locke, 'Of Ideas in general, and their Original', Paragraphs 1-8

(b) Shaftesbury, excerpts from 'Inquiry concerning Virtue or Merit'
(c) Hay, from *Deformity: An Essay*
(d) Smith, from *The Wealth of Nations*
(e) Equiano, 'The Middle Passage', excerpt from Chapter Two in *The Interesting Narrative of the Life of Olaudah Equiano; or, Gustavus Vassa, the African, Written by Himself*

Week 14 - Readings (contd); conclusions and questions

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Enlightenment
Mock epic
Satire
Novel
Periodical
Sensibility
Abolition

Sub-committee

Madhvi Zutshi, S.G.T.B. Khalsa College (Coordinator)
Nabanita Chakraborty, Hansraj College
Namita Sethi, Janki Devi College
Rudrashish Chakraborty, Kirorimal College
Sherina Joshi (Deshbandhu College)
Shyista Khan, Dyal Singh College

PAPER C7

LITERATURE AND CASTE

Semester 3

Course Statement

Caste is interwoven into Indian literatures as an analytical category and an experential narrative right from the earliest forms of creative expression. A more explicit focus on the dehumanising aspects of this hierarchical social stratification can be located in the recent times of collective living subsequent to the many radical social movements during colonial modernity. Dalit literature emerged as a political and aesthetic upheaval and continues to ask searing questions about structural inequity ever present, guarded and maintained in our midst. This course reprises those critical questions in the classroom to facilitate a deeper understanding of caste and its intersectionalities.

Course Objectives

This course aims to

- expose the student to non-hegemonic and non-canonical literary forms and expressions;
- make the student aware of a completely different literary aesthetic that a literature grounded in an engagement with caste generates;
- foreground the reality of caste, in Indian society, and to explore the way in which it has been engaged with, in the field of literature;
- discuss issues of caste, class and gender and its representation in literature; and
- expose the student to the rich variety of Dalit writing from various regional spaces.

Course Content

Unit 1

Autobiography

Om Prakash Valmiki, *Joothan: A Dalit's Life*, trans. Arun Prabha Mukerjee (Kolkata: Samya, 2003).

Unit 2

Novel

P. Sivakami, *The Grip of Change*, and author’s notes, trans. P. Sivakami (New Delhi: Orient Longman, 2016).

Unit 3
Poetry

a) Namdeo Dhasal, (i) ‘Hunger’; (ii) ‘Mandakini Patel’, in *Namdeo Dhasal: Poet of the Underworld, Poems 1972–2006*, trans., Dilip Chitre(Delhi: Navayana Publishing, 2007).
b) Meena Kandasamy, (i) ‘Touch’; (ii) ‘Shame’, in *Touch*(Mumbai: Peacock Books, 2006).
c) N. D. Rajkumar,(i) ‘My son wants me to buy him a toy car’;(ii) ‘You my demon who delights in dancing’; (iii) ‘If anyone other than our own people’, in *Poems in Tamil Dalit Writing*, eds Ravikumar and Azhagarasan (OUP, 2012) pp. 15-17.
d) Manohar Mouli Biswas,(i) ‘I shall go to war’; (ii) ‘Valmiki’, in *Poetic Rendering as Yet Unborn* (Chaturta Duniya, 2010).
e) Jayant Parmar, (i) ‘The last will of a Dalit poet’, in *Listen to the Flames: Texts and Readings From the Margins*, eds Tapan Basu, Indranil Acharya, A. Mangai (New Delhi: Oxford University Press, 2017).

Unit 4
Short Stories

a) Ajay Navaria, ‘New Custom’, trans. Laura Brueck, in *The Exercise of Freedom: An Introduction to Dalit Studies*, eds K. Sathyanarayana, Susie Tharu (New Delhi: Navayana Publishing, 2013).
b) M. M. Vinodini, ‘The Parable of the Lost Daughter: Luke 15, 11-32’, trans. Uma Bhrugubanda, in *The Exercise of Freedom: An Introduction to Dalit Studies*, eds K. Sathyanarayana, Susie Tharu (New Delhi: Navayana Publishing, 2013).
c) C. Ayyappan, ‘Spectral Speech’, trans. V. C. Harris, *Indian Literature*183, Jan-Feb, 1998.
d) Sanjay Kumar, ‘Black Ink’, trans. Raj Kumar, in *Listen to the Flames: Texts and Readings From the Margins*, eds Tapan Basu, Indranil Acharya, A. Mangai (New Delhi: Oxford University Press, 2017).
e) Jatin Bala, ‘On Firm Ground’, in *Survival and Other Stories: Bangla Dalit Fiction in Translation*, eds Sankar Prasad Singha and Indranil Acharya (New Delhi: Orient Blackswan, 2012).
f) Satish Chander, ‘Thappu’, trans. K. Suneetha Rani, in *Vibhinna: Voices from Telugu Literature*, eds Alladi Uma, M. Sridhar and K. Suneetha Rani (Sahitya Akademi, 2015).

Unit 5
Prose Readings

a) B. R. Ambedkar, ‘Annihilation of Caste’, in *The Essential Writings of B. R. Ambedkar*, ed. Valerian Rodrigues (OUP, 2002) pp. 263-305.

b) Sharankumar Limbale, 'Dalit Literature: Form and Purpose', in *Towards an Aesthetic of Dalit Literature: History, Controversies & Considerations* (Orient Longman, 2004) pp. 23-39.
c) Sharankumar Limbale, 'Dalit Literature and Aesthetics', in *Towards an Aesthetic of Dalit Literature: History,Controversies & Considerations* (Orient Longman, 2004) pp. 103-21.
d) Baby Kamble, Interview with Maya Pandit, in *The Prisons we Broke* (Orient BlackSwan, 2008).

Teaching Plan
Paper C7: Literature and Caste

Week 1 – Introduction to Paper 7: Literature and Caste
Week 2 – Unit 1 – Autobiography: Valmiki, *Joothan: A Dalit's Life*
Week 3 – Unit 1 -- Valmiki (contd)
Week 4 – Unit 2 -- Novel: Sivakami, *The Grip of Change*, and Author's Notes
Week 5 – Unit 2 -- Sivakami (contd)
Week 6 – Unit 3 -- Poems:
(a) Dhasal, (i) 'Hunger', (ii) 'Mandakini Patel';
(b) Kandasamy, (i) 'Touch', (ii) 'Shame'
Week 7 – Unit 3 -- Poems (contd):
(c) Rajkumar, (i) 'My son wants me to buy him a toy car', (ii) 'You my demon who delights in dancing';
(d) Biswas, (i) 'I shall Go to war', (ii) 'Valmiki';
(e) Parmar, 'The Last Will of a Dalit Poet'
Week 8 – Unit 4 – Short Stories:
(a) Navaria, 'New Custom';
(b) Vinodini, 'The Parable of the Lost Daughter: Luke 15'
Week 9 – Poetry (contd)
Week 9 -- Unit 4 -- Short Stories:
(a) Ayyappan, 'Spectral Speech'; Kumar, 'Black Ink'
Week 10 -- Unit 4 - Short Stories (contd):
(b) Bala, 'On Firm Ground'; Chander, 'Thappu'
Week 11 – Unit 5 -- Prose Readings:
(a) Ambedkar, 'Annihilation of Caste'
Week 12 – Unit 5 -- Prose Readings (contd):
(b) Limbale, (i) 'Dalit Literature: Form and Purpose', (ii) 'Dalit Literature and Aesthetics'
Week 13 -- Unit 5 - Prose Readings (contd):Kamble, interview with Maya Pandit
Week 14 -- Concluding lectures; exam issues, etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Caste
Caste Hierarchy
Caste discrimination
Dalit
Dalit Literature
Dalit Aesthetics
Dalit Women
Protest
Resistance

Sub-committee

Jenny Rowena, Miranda House, (Coordinator)
B. Mangalam, Lakshmibai College
Brati Biswas, Dyal Singh College (Evening)
Sachin N., Dyal Singh College
Mithuraaj Dhusiya, Hansraj College
Gorvika Rao, Miranda House College

PAPER C8

BRITISH LITERATURE 4: THE ROMANTICS

Semester 4

Course Statement

This paper focuses on the Romantic period of English literature and covers a historical span of about 40 years (1789-1830). Individual units deal with both canonical and non-canonical writers of the period.

Course Objectives

This course aims to

- introduce students to the Romantic period in English literature, a period of lasting importance, since it serves as a critical link between the Enlightenment and Modernist literature;
- offer a selection of canonical poems and prose that constitute the core texts of the Romantic period;
- introduce marginal voices that were historically excluded from the canon of British Romantic writers; and
- provide an introduction to important French and German philosophers who influence the British Romantic writers.

Course Content

Unit 1

a) William Blake, from *Songs of Innocence and Experience*, (i) 'Introduction' (to *Songs of Innocence*); (ii) 'Lamb'; (iii) 'Tiger'; (iv) 'Chimney Sweeper' (*Songs of Innocence*); (v) 'Chimney Sweeper' (*Songs of Experience*); (vi) 'Holy Thursday' (*Songs of Innocence*); (vii) 'Holy Thursday' (*Songs of Experience*); (viii) 'The Little Black Boy'; (ix) 'London'.
b) Charlotte Smith, (i) 'To Melancholy'; (ii) 'Nightingale'

Unit 2

a) William Wordsworth, (i) 'Lines Composed a Few Miles Above Tintern Abbey'; (ii) 'Ode: Intimations of Immortality'.
b) Samuel Coleridge, (i) 'Kubla Khan'; (ii) 'Dejection: An Ode'

Unit 3

a) John Keats, (i) 'Ode to a Nightingale'; (ii) 'Ode on a Grecian Urn'; (iii) 'Ode to Autumn'.
b) Percy Shelley, (i) 'Ozymandias; (ii) 'Ode to the West Wind'

Unit 4

Mary Shelley, *Frankenstein*.

Unit 5
Readings

a) Mary Wollstonecraft, *A Vindication of the Rights of Woman*, Chapters 1 and 3 (Cambridge University Press, 2001) pp. 79-86, 109-125.
b) J. J. Rousseau, 'Discourse on the Origin of Inequality', Part One, in *Jean-Jacques Rousseau: Basic Political Writings* (Hackett Publishing Company, 1987) pp. 37-60.
c) Immanuel Kant, 'Analytic of the Sublime', in*The Critique of Judgment* (Cambridge University Press, 2001) pp. 128-49.
d) William Wordsworth, 'Preface to Lyrical Ballads', in *Romantic Prose and Poetry*, ed. Harold Bloom and Lionel Trilling (New York: OUP, 1973) pp. 594–611.
e) William Gilpin, 'On Picturesque Travel', in *Three Essays: On Picturesque Beauty.*

Teaching Plan
Paper C8: British Literature 4 – The Romantics

Week 1 -- Introduction to the Romantic period;
Blake: From *Songs of Innocence and Experience*, (i) 'Introduction' to *Songs of Innocence*; (ii) 'Lamb'; (iii) 'Tiger'; (iv) 'Chimney Sweeper' (*Songs of Innocence*); (v) 'Chimney Sweeper' (*Songs of Experience*); (vi) 'Holy Thursday' (*Songs of Innocence*); (vii) 'Holy Thursday' (*Songs of Experience*); (viii) 'The Little Black Boy'; (ix) 'London'
Week 2 – Blake (contd)
Week 3 – Blake (contd);
Smith, (i) 'To Melancholy', (ii) 'Nightingale'
Week 4 – Wordsworth, (i) 'Lines Composed a Few Miles Above Tintern Abbey'; (ii) 'Ode: Intimations of Immortality'.
Week 5 -- Wordsworth (contd)
Week 6 – Coleridge, (i) 'Kubla Khan', (ii) 'Dejection: An Ode'
Week 7 – Keats, (i) 'Ode to a Nightingale'; (ii) 'Ode on a Grecian Urn'; (iii) 'Ode to Autumn'
Week 8 – Keats (contd); Shelley, (i) 'Ozymandias; (ii) 'Ode to the West Wind'
Week 9 -- Shelley (contd)
Week 10 – Mary Shelley, *Frankenstein*
Week 11 -- Mary Shelley (contd)
Week 12 -- Readings:
(a) Mary Wollstonecraft, *A Vindication of the Rights of Woman*, Chapters 1 and 3;
(b) Rousseau, 'Discourse on the Origin of Inequality', Part One;

(c) Kant, 'Analytic of the Sublime';
(d) Wordsworth, 'Preface to Lyrical Ballads';
(e) Gilpin, 'On Picturesque Travel'

Week 13 – Readings (contd)
Week 14 –Readings (contd)

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Imagination
Nature
French Revolution
Sublime
Science

Sub-committee

N. A. Jacob, Ramjas College (Coordinator)
B. Mangalam, Aryabhatta College
Mudita Mohile, Gargi College
Rina Ramdev, Sri Venkateswara College
Rudrashish Chakrabarty, Kirori Mal College
Sherina Joshi, Deshbandhu College

PAPER C9

BRITISH LITERATURE 5: THE NINETEENTH CENTURY

Semester 4

Course Statement

This paper focuses on the Victorian period of English literature and covers a large historical span from 1814 to 1900. Individual units deal with important examples of the novel form, with one unit on Victorian poetry.

Course Objectives

This course aims to

- introduce students to the Victorian Age in English literature through a selection of novels and poems that exemplify some of the central formal and thematic concerns of the period;
- focus on three novels, a major genre of the nineteenth century, so as to show both the formal development of the genre as well as its diverse transactions with the major socio-historic developments of the period; and
- introduce the students, through the readings in Unit 5, to the main intellectual currents of the period.

Course Content

Unit 1

Jane Austen, *Mansfield Park.*

Unit 2

Charles Dickens, *Great Expectations.*

Unit 3

George Eliot, *The Mill on the Floss.*

Unit 4

a) Alfred Tennyson, (i) ‘Ulysses’; (ii) ‘Crossing the Bar’.
b) Robert Browning, (i) ‘My Last Duchess’; (ii)‘Andrea del Sarto’.
c) Mathew Arnold,‘Dover Beach’.
d) Christina Rossetti,‘Goblin Market’.
e) Gerard M. Hopkins,‘Hurrahing in the Harvest’.
f) Thomas Hardy,‘The Darkling Thrush’.

Unit 5
Readings

a) Thomas Carlyle,'Signs of the Times'.
b) Oscar Wilde,'The Critic as Artist'
c) J. S. Mill, 'Of the Limits to the Authority of Society over the Individual, from 'On Liberty'.
d) Karl Marx, (i) 'Mode of Production: The Basis of Social Life'; (ii) 'The Social Nature of Consciousness', both in *A Reader in Marxist Philosophy*, ed. Howard Selsam and Harry Martel (International Publishers,1963) pp. 186–8, 190–1; 199–201.
e) Charles Darwin, excerpts from 'On Origin of Species by Means of Natural Selection', from Chapter 3; from Chapter 4, ed. Joseph Caroll (Broadview Press, 2003) pp. 132-34; 144-162.

Teaching Plan
Paper C9: British Literature 5 – The Nineteenth Century

Week 1 – Introduction to the Nineteenth Century; Unit 1 -- Austen, *Mansfield Park*
Week 2 -- Austen (contd)
Week 3 -- Austen (contd)
Week 4 -- Unit 2 -- Dickens, *Great Expectations*
Week 5 -- Dickens (contd)
Week 6 -- Dickens (contd)
Week 7 -- Unit 3 -- George Eliot, *The Mill on the Floss*
Week 8 -- George Eliot (contd)
Week 9 -- George Eliot (contd)
Week 10 - Poetry:
(a) Tennyson, (i) 'Ulysses', (ii) 'Crossing the Bar';
(b) Browning, (i) 'My Last Duchess', (ii) 'Andrea del Sarto';
(c) Arnold, 'Dover Beach';
(d) Rossetti, 'Goblin Market';
(e) Hopkins, 'Hurrahing in the Harvest';
(f) Hardy, 'The Darkling Thrush'
Week 11 – Poetry (contd)
Week 12 – Poetry (contd)
Week 13 -- Readings:
(a) Carlyle, 'Signs of the Times';
(b) Wilde, 'The Critic as Artist';
(c) Mill, 'Of the Limits to the Authority of Society over the Individual', from 'On Liberty';
(d) Marx, (i) 'Mode of Production: The Basis of Social Life', (ii) 'The Social Nature of Consciousness';
(e) Darwin, excerpts from 'On the Origin of the Species by Means of Natural Selection'
Week 14 -- Readings (contd)

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Realism
Novel
Industrial Revolution
Liberalism
Feminism
Bourgeois
Socialism
Darwinism

Sub-committee

Karuna Rajeev, Lady Shri Ram College (Coordinator)
N. A. Jacob, Ramjas College
B. Mangalam, Aryabhatta College
Mudita Mohile, Gargi College
Rudrashish Chakrabarty, Kirori Mal College
Shyista Khan, Dyal Singh College

PAPER C10

WOMEN'S WRITING

Semester 4

Course Statement

This paper focuses on writings by women, about women. Since women are always defined in relation to men in a structurally patriarchal society, women writing about their experiences and identities are almost always writing about their community, since they do not have the privilege to write about themselves as individuals inhabiting a certain position in society. This paper focuses on those stories, poems, plays, novels, autobiographies, and theoretical writings that most clearly articulate the struggle to define experiences, and challenge patriarchal constructs. The texts in this paper focus on gender and sexuality as related to women, their bodies, their desires, and their aspirations. However, women do not form a homogenous group and their oppressions and acts of resistance need to be understood in all their complexities. Therefore, the intersectionality of the position of womanhood with caste, class, race, disability, education, slavery etc.,need to be studied with attention to the socio-economic historical location.

Course Objectives

This course aims to

- help students understand the social construction of woman by patriarchy;
- examine feminism's concerns of equality with men;
- highlight the structural oppression of women;
- foreground resistance by women;
- discuss women's writing as an act of resistance and of grasping agency;
- facilitate an understanding of the body of woman and its lived experience; and
- help students engage with the heterogeneity of the oppression of women in different places, historically and socially.

Course Content

Unit 1

Alice Walker, *The Color Purple*

Unit 2

Short Stories

a) Gilman, 'The Yellow Wallpaper'

b) Mahasweta Devi, 'Draupadi'

c) Anne Finger, 'Helen and Frida', in *Call me Ahab: A Short Story Collection*, (University of Nebraska Press, 2009) pp. 1-14.

Drama

Maria Irene Fornes, *Fefu and Her Friends*.

Unit 3
Poetry

a) Simin Behbahani, 'It's Time to Mow the Flowers'.
b) Maram al-Masri, (i) 'Liberty's children'; (ii) 'Wooden crates, wooden crates';
c) Sylvia Plath, (i) 'Lady Lazarus'; (ii) 'Mirror'.
d) Sukirtharani, (i) 'Debt'; (ii) 'My Body', in *The Oxford Anthology of Tamil Dalit Writing*, eds Ravikumarn, R. Azhagarasan (OUP, 2012) pp. 28-30.
e) Eunice DeSouza, (i) 'Autobiographical';(ii) 'Advice to Women'.
f) Margaret Atwood, (i) 'Is/Not'; (ii) 'Notes towards a poem that can never be written'
g) Maya Angelou, 'Still I Rise'.
h) Jamaica Kincaid, 'Girl'.

Unit 4
Autobiography

a) Rassundari Debi, Excerpts from 'Amar Jiban', in *Women's Writing in India*, Vol. 1, eds Susie Tharu and K. Lalita, (Delhi: Oxford, 1989) pp. 191-202.
b) Bama, *Sangati, Events*, Chapter 2-4, trans. Lakshmi Holmstrom (Delhi, OUP: 2005).
c) Florence Nightingale, *Cassandra* (The Feminist Press, 1979).
d) Harriet Jacobs, selections from *Incidents in the Life of a Slave Girl*, Chapters 5, 6, 10, 14.

Unit 5
Readings

a) Elaine Showalter, 'Introduction', in *A Literature of Their Own: British Women Novelists from Bronte to Lessing* (1977).
b) Simone de Beauvoir, 'Introduction', in *The Second Sex.*
c) Luce Irigaray, 'When the Goods Get Together', in *This Sex Which Is Not One*.
d) Rosemarie Garland-Thomson, 'Integrating Disability, Transforming Feminist Theory', in *The Disability Studies Reader*, ed. Lennard J. Davis, 2nd edition (London and New York: Routledge, 2006) pp. 257-73.
e) Kumkum Sangari and Sudesh Vaid, 'Introduction', in *Recasting Women: Essays in Colonial History*

Teaching Plan
Paper C10: Women's Writing

Week 1 – Introduction to Paper C10: Women's Writing
Week 2 – Unit 1 – Novel: Walker, *The Color Purple*
Week 3 – Walker (contd)
Week 4 – Unit 2 -- Short Stories:
(a) Gilman, 'The Yellow Wallpaper';
(b) Mahasweta Devi, 'Draupadi';
(c) Anne Finger, 'Helen and Frida'
Week 5 – (a) Short Stories (contd);

(b) Unit 2 – Drama: Fornes, *Fefu and Her Friends*

Week 6 – Fornes (contd)

Week 7 – Unit 3 – Poetry:

(a) Behbahani, 'It's Time to Mow the Flowers';
(b) al-Masri, (i) 'Liberty's children'; (ii) 'Wooden crates, wooden crates';
(c) Plath, (i) 'Lady Lazarus'; (ii) 'Mirror';
(d) Sukirtharani, (i) 'Debt'; (ii) 'My Body';
(e) DeSouza, (i) 'Autobiographical'; (ii) 'Advice to Women';
(f) Atwood, (i) 'Is/Not'; (ii) 'Notes towards a poem that can never be written';
(g) Angelou, 'Still I Rise';
(h) Kincaid, 'Girl'

Week 8 – Poetry (contd)

Week 9 – Poetry (contd)

Week 10 – Unit 4 – Autobiography:

(a) Rassundari Debi, Excerpts from *Amar Jiban*;
(b) Bama, *Sangati, Events*, Chapter 2-4;
(c) Nightingale, *Cassandra*;
(d) Jacobs, selections from *Incidents in the Life of a Slave Girl*, Chapters 5, 6, 10, 14.

Week 11 – Autobiography (contd)

Week 12 – Unit 5 -- Prose Readings:

(a) Showalter, 'Introduction', in *A Literature of Their Own*;
(b) de Beauvoir, 'Introduction', in *The Second Sex*;
(c) Irigaray, 'When the Goods Get Together';
(d) Garland-Thomson, 'Integrating Disability, Transforming Feminist Theory'
(e) Sangari and Vaid, 'Introduction', in *Recasting Women*

Week 13 – Prose Readings (contd)

Week 14 – Concluding lectures; exam issues, etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments

3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Women writers
Women poets
Women's confessional poetry Women novelists
Women playwrights Women's autobiography Women theorists
Feminist writers
Gender
Patriarchy

Sub-committee

Vinita Chandra, Ramjas College (Coordinator)
B. Mangalam, Lakshmibai College
Rina Ramdev, Sri Venkateshwara College
Roopa Dhawan, Ramjas College
Shyista Khan
Someshwar Sati, Kirorimal College

PAPER C11
BRITISH LITERATURE 6 – THE TWENTIETH CENTURY
Semester 5

Course Statement

This paper provides a broad view of 20th century British literature, both in terms of time and genre. The transition from 19th century literary and artistic methods and forms to the growth of modernism in England cannot be understood without referring to similar developments on the continent. The inclusion of Baudelaire in the prose readings is an important step in charting this transition and its theoretical underpinnings. The course is also designed to include critical and radical perspectives on questions of war, the nature of art, and the relationship between individuals and the state in the 20th century. Finally the course also addresses questions relating to peculiarly modern forms of subjectivity and selfhood without which our existence within the modern world cannot be understood or analysed.

Course objectives

This course aims to

- develop an understanding among students of the various forms of critique of modernity that evolved in England (and Europe) in the course of the 20^{th} century;
- help students comprehend the path-breaking and avant-garde forms of literary expression and their departures from earlier forms of representations;
- facilitate an understanding of the impact of the two world wars on literary expression and the various political/ideological positions of the European intelligentsia vis-à-vis the phenomenon; and
- createawareness of new disciplines/areas of inquiry that decisively influenced European art and literature in the 20^{th} century.

Course Content

Unit 1

Joseph Conrad, (i) *Heart of Darkness* (London: Penguin, 2007); (ii) Preface to 'The Nigger of the Narcissus', in *The Portable Conrad*, ed. Michael Gorra London: Penguin, 2007) pp. 93-96.

Unit 2

Virginia Woolf, (i) *Mrs. Dalloway* (London: Penguin, 2000).; (ii) 'Mr. Bennett and Mrs. Brown', in *Virginia Woolf: Selected Essays* (London: Oxford World Classics, 2008) pp. 85-88.

Unit 3

Samuel Beckett, *Waiting for Godot* (New York: Grove Press, 2011).

Unit 4

a) W.B. Yeats, (i) 'Sailing to Byzantium; (ii) 'The Second Coming'; both in *W.B. Yeats: Collected Poems* (London: Macmillan, 2017).
b) T.S. Eliot, (i) 'The Love Song of J. Alfred Prufrock'; (ii) 'The Hollow Men; both in*T.S. Eliot: Selected Poems* (London: Faber, 2015).
c) W.H. Auden, (i) 'Musee Des Beaux Arts'; (ii) 'The Unknown Citizen'; both in *W. H. Auden: Selected Poems* (London: Vintage, 2007).
d) Wilfred Owen, 'Strange Meeting', in *Wilfred Owen: Collected Poems* (N.Y.: New Directions, 2013).

Unit 5
Readings

a) Charles Baudelaire, (i) From 'The Painter of Modern Life'; (ii) 'Modernity'; (iii) 'Women and Prostitutes'; all in *Modern Art and Modernism: A Critical Anthology*, ed. Francis Frascina & Charles Harrison (Colorado: Westview, 1987) pp. 23-27.
b) Sigmund Freud, 'The Structure of the Unconscious, the Id, the Ego and the Superego', in *Background Prose Readings* (Delhi: Worldview, 2001) pp. 97-104.
c) Albert Camus, (i) 'Absurdity and Suicide'; (ii) 'The Myth of Sisyphus', trans. Justin O'Brien, in *The Myth of Sisyphus* (London: Vintage, 1991) pp. 13-17; 79-82.
d) D.H. Lawrence, 'Morality and the Novel', in *The Modern Tradition: Backgrounds of Modern Literature*, eds Richard Ellmann and Charles Feidelson, Jr (Oxford University Press 1965).
e) Raymond Williams, 'Metropolitan Perceptions and the Emergence of Modernism', in *Raymond Williams. The Politics of Modernism* (London: Verso, 1996) pp. 37-48.

Teaching Plan
Paper C11: British Literature 6 – The Twentieth Century

Week 1 – Introduction to Paper C11: Twentieth Century British Literature
Week 2 – Unit 1 – Novel: Conrad, *Heart of Darkness*
Week 3 – Conrad (contd)
Week 4 – Unit 2 – Novel: Woolf, *Mrs Dalloway*
Week 5 – Woolf (contd)
Week 6 – Unit 3: Drama: Beckett, *Waiting for Godot*
Week 7 – Beckett (contd)
Week 8 – Unit 4: Poetry:

- (a) Yeats: (i) 'Sailing to Byzantium, (ii) 'The Second Coming
- (b) Eliot: (i) 'The Love Song of J. Alfred Prufrock', (ii) 'The Hollow Men;
- (c) Auden: (i) 'Musee Des Beaux Arts', (ii) 'The Unknown Citizen';
- (d) Owen, 'Strange Meeting'

Week 9 – Poetry (contd)
Week 10 – Poetry (contd)
Week 11 – Unit 5 -- Prose Readings:

- (a) Baudelaire: (i) From 'The Painter of Modern Life', (ii) 'Modernity', (iii) 'Women and Prostitutes'
- (b) Freud, 'The Structure of the Unconscious, the Id, the Ego and the Superego'
- (c) Camus, (i) 'Absurdity and Suicide'; (ii) 'The Myth of Sisyphus'
- (d) Lawrence, 'Morality and the Novel'
- (e) Raymond Williams, 'Metropolitan Perceptions and the Emergence of Modernism'

Week 12 – Prose Readings (contd)
Week 13 – Prose Readings (contd)
Week 14 – Concluding lectures; exam issues, etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Modernity
Modernism
Unconscious
Metropolis
Myth

Sub-committee

Anshuman Singh, Dyal Singh College (Coordinator)
Madhvi Zutshi, SGTB Khalsa College
N.A Jacob, Ramjas College
Nabanita Chakraborty, Hansraj College
Rudrashish Chakraborty, KMC
Someshwar Sati, KMC

PAPER C12
FORMS OF POPULAR FICTION
Semester 5

Course Statement

The paper will trace the emergence of a mass printing culture from the 19th century onwards, and the rise of genres such as Literature for Children, Science Fiction, Detective and Spy Fiction, and Romance. The course introduces students to the idea of 'popular literature' and stresses its importance within modern culture. It familiarises students with the debate between 'high' and 'low' culture, and the tension between what is studied as 'canonical' texts and other texts. Students will also engage with issues concerning print culture, bestsellers, and popular literature in other media.

Course Objectives

This course aims to

- enable students to trace the rise of print culture in England, and the emergence of genre fiction and bestsellers;
- familiarize students with debates about culture, and the delineation of high and low culture; and
- help them engage with debates about the canonical and non-canonical, and hence investigate the category of literary and non-literary fiction.

Course Content
Unit 1
Literature for Children

a) Lewis Carroll,'Through the Looking Glass', in *Alice's Adventures in Wonderland and Through the Looking Glass*, ed. Hugh Haughton (Penguin Classics: London, 1998).
b) Sukumar Ray, (i) 'The Sons of Ramgaroo'; (ii) 'Stew Much'; both in *A Few Poems by Sukumar Ray*, trans. Satyajit Ray (Open Education Project OKFN, India) pp. 4, 12.https://in.okfn.org/files/2013/07/A-Few-Poems-by-Sukumar-Ray.pdf

Unit 2
Detective and Spy Fiction

a) Edgar Allan Poe, 'The Murders in the Rue Morgue', in *The Murders in the Rue Morgue and Other Tales* (London: Penguin Classics, 2012).
b) Arthur Conan Doyle, 'The Five Orange Pips', in *The Five Orange Pips and Other Cases* (London: Penguin, 2012).
c) Agatha Christie, 'The Tuesday Night Club', in *Miss Marple: The Complete Short Stories* (New York: Harper, 2011) pp. 1-15.
d) Ian Fleming, 'Risico', in *Quantum of Solace: The Complete James Bond Short Stories* (London: Penguin, 2008) pp. 102-141.

Unit 3
Romance

Daphne Du Maurier, *Rebecca* (London: Virago Modern Classics, 2003).

Unit 4
Science Fiction

a) Isaac Asimov, 'Nightfall', in *Isaac Asimov: The Complete Short Stories. Vol I.* (New York: Broadway Books, 1990) pp. 334-62.
b) Ursula le Guin, 'The Ones Who Walk away from Omelas', in *The Wind's Twelve Quarters and The Compass Rose* (London: Orion Books, 2015) pp. 254-62.
c) Philip K. Dick, 'Minority Report', in *The Complete Stories of Philip K. Dick Vol. 4: The Minority Report and Other Classic Stories* (Citadel Books: New York, 1987) pp. 62-90.
d) Ray Bradbury, 'A Sound of Thunder', in *A Sound of Thunder and Other Stories* (New York: William Morrow, 2005).
e) Jayant Narlikar, 'Adventure', available at https://archive.org/stream/TheAdventure-JayantNarlikar/narlikar-adventure_djvu.txt

Unit 5
Readings

a) Christopher Pawling, 'Popular Fiction: Ideology or Utopia?', in *Popular Fiction and Social Change*, ed. Christopher Pawling (London: Macmillan, 1984).
b) Felicity Hughes, 'Children's Literature: Theory and Practice', *ELH* 45 (1978), pp. 542-62.
c) Darko Suvin, 'On Teaching SF Critically', in *Positions and Presuppositions in Science Fiction* (London: Macmillan), pp. 86-96.
d) Todorov, Tzvetan. 'The Typology of Detective Fiction', trans. Richard Howard, in *The Poetics of Prose* (Ithaca: Cornell University Press, 1977).
e) Radway, Janice, 'The Institutional Matrix: Publishing Romantic Fiction', in *Reading the Romance: Women, Patriarchy, and Popular Literature* (University of North Carolina Press, 2009).

Teaching Plan
Paper C12: Forms of Popular Fiction

Week 1 – Introduction to Forms of Popular Fiction; [it is suggested that the reading for each section be done as an introduction to each of the genres represented];
Unit 5 – (a) Pawling, 'Popular Fiction: Ideology or Utopia?'
Week 2 – Unit 1 – Literature for Children: Introduction;
Unit 5 – (b) Hughes, 'Children's Literature: Theory and Practice';
Unit 1 – (a) Carroll, 'Through the Looking Glass';
(b) Ray, (i) 'The Sons of Ramgaroo'; (ii) 'Stew Much'
Week 3 – Carroll and Ray (contd)

Week 4 – Carroll and Ray (contd)
Week 5 – Unit 2 --Detective and Spy Fiction, Introduction;
Unit 5 – Todorov, 'The Typology of Detective Fiction';
Unit 2 – (a) Poe, 'The Murders in the Rue Morgue';
(b) Doyle, 'The Five Orange Pips'
Week 6 – Unit 2 (contd):
(c) Christie, 'The Tuesday Night Club';
(d) Fleming, 'Risico'
Week 7 – Unit 3 – Romance, introduction;
Unit 5 – (e) Radway, 'The Institutional Matrix: Publishing Romantic Fiction'
Unit 3 -- Du Maurier, *Rebecca*
Week 8 – Du Maurier (contd)
Week 9 – Unit 4 – Science Fiction, introduction;
Unit 5 -- Suvin, 'On Teaching SF Critically';
Unit 4:
(a) Asimov 'Nightfall';
(b) le Guin 'The ones who walk away from Omelas'
Week 10 – Unit 4 (contd)
Week 11 – Unit 4 (contd):
(c) Dick 'Minority Report';
(d) Bradbury 'A Sound of Thunder;
(e) Narlikar 'Adventure'
Week 12 – Unit 4 (contd)
Week 13 – Unit 4 (contd)
Week 14 – Concluding lectures; exam issues, etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Popular Culture
Mass Culture
Popular Fiction
Popular Literature
Romance
DetectiveFiction
Spy Fiction
Science Fiction
Children's Literature
Bestsellers
Thrillers

Sub-committee

Nidhi Bhandari, Kamala Nehru College (Coordinator)
Sanam Khanna, Kamala Nehru College
Madhumita Chakraborty, Zakir Hussain College
Neha Singh, Kamala Nehru College
Nitya Dutta, Sri Venkateswara College
Shraddha A. Singh, Zakir Hussain College

PAPER C13
MODERN EUROPEAN DRAMA
Semester 6

Course Statement

This is a genre-based and performance-oriented paper. It provides an overview of formative theatrical movements in Europe. The plays included focus on innovative performance trends that began at the end of the nineteenth century and evolved into diverse forms in the twentieth century. Some of these are naturalism, expressionism, epic theatre and the theatre of the absurd. The impact of these new directions radiated across the globe and gave a new impetus to drama in the twentieth century. A deep engagement of theatre with important social issues of the time was central to these developments. The course focuses on the work of significant European playwrights from the late nineteenth century to the late twentieth century; a span of almost a century has been covered.

The lived lives of people had a direct bearing with their representation on stage. At the level of performance, the shift from the naturalistic set-up to the more flexible epic theatre can be observed through these texts. Courses on Modern European Drama have generally been marked by a lack of women's voices. The presence of Franca

Rame's 'Rape' along with Dario Fo's *Can't Pay, Won't Pay*enables a gendered perspective more grounded in the realities of the time.

Course Objectives

This course aims to

- provide students with an overview of how modernity was introduced in the twentieth century through drama;
- help students understand the dynamic relationship between actors and audience, and to observe the transition from passive spectatorship to a more active and vital participatory process visible in newer forms in the 1970s;
- examine Ibsen's *A Doll's House* as it focuses on issues related to women in patriarchal institutions such as marriage;
- provide students with a broader picture of modern drama with a focus on new trends at the turn of the century, through a study of Chekov's *The Cherry Orchard*;
- look at ideas of alienation in epic theatre, through a study of Brecht's *Caucasian Chalk Circle*, and to link those ideas to Brecht's prose works in Unit 5;
- examine Genet's *The Balcony*and its critiques of absurd theatre, in contrapuntal discourse with Ionesco's prose writings, *Present Past, Past Present*; and
- sensitise students about feminist interventions in the European theatrical tradition, through Rame's 'Rape' and Fo's *Can't Pay, Won't Pay.*

Course Content

Unit 1

a) Henrik Ibsen, *A Doll's House*, trans. Michael Meyer (London: Bloomsbury, 2008).
b) Anton Chekov, *The Cherry Orchard*, trans. Michael Frayn (London: Methuen, 1978).

Unit 2

Bertolt Brecht, *Caucasian Chalk Circle*, trans. Alistair Beaton (London: Bloomsbury 2015).

Unit 3

Jean Genet, *The Balcony*, trans. Bernard Frechtman (New York: Grove Press, 1994).

Unit 4

a) Dario Fo, *Can't Pay, Won't Pay*, trans. Lino Pertile (London: Methuen, 1987).

b) Franca Rame, 'Rape', trans. Gilliana Hanna, ed. Emery (London: Bloomsbury, 1991) pp. 83-88.

Unit 5

Readings

a) August Strindberg,'Preface to Miss Julie', in *Miss Julie*, trans. Helen Cooper (London: Methuen, 1992) pp. xixxv.

b) Bertolt Brecht, (i) 'The Street Scene';(ii) 'Theatre for Pleasure or Theatre for Instruction'; (iii) 'Dramatic Theatre vs Epic Theatre', in *Brecht on Theatre: The Development of an Aesthetic*, ed. John Willet (London: Methuen, 1992) pp. 121-28; 68-76; chart, p. 31.

c) Eugene Ionesco, (i) 'Still About Avant-Garde Theatre' (ii) 'Remarks on my Theatre and on the Remarks of Others', in *Notes And Counter Notes: Writings on the Theatre*, trans. Donald Watson (New York: Grove Press, 1964) pp. 53-58; 59-82; (iii) Selection from *Present Past, Past Present*, trans. Helen R. Lane (USA: De Capo Press, 1998) pp. 77-82.

d) 'Dario Fo's Nobel Lecture' (Stockholm: The Nobel Foundation, 1997).

e) Konstantin Stanislavski, 'Faith and the Sense of Truth', sections 1, 2, 7, 8, 9, Chapter 8, in *An Actor Prepares* (Penguin) pp. 121-5, 137-46.

Teaching Plan

Paper C13: Modern European Drama

Week 1 – Introduction to Modern European Drama
Week 2 – Unit 1 – Ibsen: *A Doll's House*
Week 3 – Ibsen (contd); Unit 1 – Introduction to Chekov, *The Cherry Orchard*
Week 4 – Chekov (contd)
Week 5 – Unit 2 – Brecht, *The Caucasian Chalk Circle*
Week 6 – Brecht (contd)
Week 7 – Unit 3 – Genet, *The Balcony*
Week 8 – Genet (contd)
Week 9 – Unit 4 – Fo, *Can't Pay, Won't Pay*
Week 10 – Fo (contd); Introduction to Rame, 'Rape'
Week 11 – Rame (contd)
Week 12 – Unit 5 – Prose Readings:

(a) Strindberg, Preface to *Miss Julie*;
(b) Brecht, 'The Street Scene' (pp. 121-8), 'Theatre for Pleasure or Theatre for Instruction' (pp. 68-76) and 'Dramatic Theatre vs. Epic Theatre' (chart) (p. 31);
(c) Ionesco, 'Still About Avant-Garde Theatre' (pp. 53-58), 'Remarks on my Theatre and on the Remarks of Others' (pp. 59-82)

Week 13 – Prose Readings (contd):

(c) Ionesco, selection from *Present Past, Past Present*;

(d) Fo, 'Nobel Lecture';

(e) Stanislavski, Chapter 8, 'Faith and the Sense of Truth', Sections of *An Actor Prepares*, Sections 1, 2, 7, 8, 9 (pp. 121-55, 137-46).

Week 14 – Concluding lectures; exam issues, etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Naturalism
Expressionism
Epic Theatre
Theatre of the Absurd
Naturalism
Fourth Wall
Alienation effect
Defamiliarisation

Sub-committee

Payal Nagpal, Janki Devi Memorial College (Coordinator)
B. Mangalam, Aryabhatta College
Karuna Rajeev, Lady Shri Ram College
Manpreet Kaur, Shyama Prasad Mukherjee College
Rudrashish Chakravorty, Kirori Mal College
Sanjay Kumar, Hansraj College

PAPER C14
POSTCOLONIAL LITERATURES
Semester 6

Course Statement

This paper critically engages with postcolonial studies and its surrounding debates and seeks to uncover silenced voices, while moving the majoritarian viewpoint to the margins. It therefore puts into question the ideas of centres and margins of cultural spaces, and definitions of mainstream and 'vernacular' discourses. Literatures from Africa, the Caribbean, Latin America, and the Indian sub-continent are included to address the relationship between history and literature through multiple points of enquiry.

Course Objective

The paper aims to

- introduce the students to postcolonial theorisations and texts from hitherto colonized regions;
- demonstrate an awareness of the postcolonial situation through the reading of a wide variety of texts;
- familiarize students with of the variety of postcolonial literatures from Africa, Latin America and South Asia and to counter the stereotypes usually associated with assumptions regarding these literatures;
- inculcate adequate knowledge of the importance of gender, class, and caste issues in postcolonial literatures; and
- expose students to various genres of writing: the novel, drama, short stories, prose writings, critical essays and poetry.

Unit 1

Chinua Achebe (Nigeria), *Things Fall Apart.*

Unit 2

Amitav Ghosh (India), *The Shadow Lines.*

Unit 3

a) Ngugi wa Thiongo (Kenya), *The Trial of Dedan Kemathi.*
b) Indra Sinha (India),*Animal's People* (Tape 1, 2 and 3).

Unit 4
Short Stories

a) Bessie Head (South Africa/Botswana), 'The Collector of Treasures'.
b) Ama Ata Aidoo (Ghana), 'The Girl Who Can'.
c) Gabriel Garcia Marquez (Colombia), 'Big Mama's Funeral'.
d) Carlos Fuentes (Mexico), 'Chac Mool'.

Poems

a) Pablo Neruda (Chile), 'Ode to the Tomato'.
b) Derek Walcott (West Indies), 'Goats and Monkeys'.
c) Aga Shahid Ali (India), 'Dacca Gauzes'.
d) Fehmida Riaz (Pakistan), 'Tum Bilkul Hum Jaise Nikle'/Purvanchal.

Unit 5
Readings

a) Edward Said, 'Introduction', in *Orientalism* (Harmondsworth: Penguin, 1978).
b) Robert Young, 'Colonialism and the Politics of Postcolonial Critique', in *Postcolonialism: An Historical Introduction* (Blackwell Publishing, 2001) pp. 1-11.
c) Ngugi wa Thiongo, 'The Language of African Literature', Chapter 1, Sections 4-6, in*Decolonising the Mind.*
d) Aijaz Ahmad,''Indian Literature': Notes towards the Definition of a Category', in *In Theory: Classes, Nations, Literatures* (London: Verso, 1992).
e) Neil Lazarus, 'Introduction', in *The Postcolonial Unconscious* (Cambridge: OUP, 2011) pp. 5-18.

Teaching Plan
Paper C14: Postcolonial Literatures

Week 1 – IntroductionPostcolonial Literatures
Week 2 – Unit 1 – Novel: Achebe, *Things Fall Apart*
Week 3 – Achebe (contd)
Week 4 – Unit 2 -- Novel: Ghosh, *The Shadow Lines*
Week 5 – Ghosh (contd)
Week 6 – Unit 3 -- Drama: Ngugi, *The Trial of Dedan Kemathi.*
Week 7 – Ngugi (contd)
Week 8 – Unit 3 -- Sinha,*Animal's People* (Tape 1, 2 and 3)
Week 9 – Unit 4 -- Short Stories:
(a) Head, 'The Collector of Treasures';
(b) Aidoo, 'The Girl Who Can';
(c) Marquez, 'Big Mama's Funeral';
(d) Fuentes, 'Chac Mool'

Week 10 -- Unit 4 – Short Stories (contd)
Week 11 – Unit 4 – Poetry:
(a) Neruda, 'Ode to the Tomato';
(b) Walcott, 'Goats and Monkeys';
(c) Ali, 'Dacca Gauzes';
(d) Riaz, 'Tum Bilkul Hum Jaise Nikle'/Purvanchal
Week 12 – Unit 5 -- Readings:
(a) Said, 'Introduction', in *Orientalism*;
(b) Young, 'Colonialism and the Politics of Postcolonial Critique';
(c) Ngugi, 'The Language of African Literature';
(d) Ahmad, ''Indian Literature': Notes towards the Definition of a Category';
(e) Lazarus, 'Introduction', in *The Postcolonial Unconscious*
Week 13 – Prose Readings (contd)
Week 14 – Concluding lectures; exam issues, etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups, initiating discussion topics, participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Postcolonial
Marginalisation
Culture
Decolonisation
Identity

Sub-committee

Madhumita Chakraborty, Zakir Husain Delhi College (E) (Coordinator)
Garima Yadav, Bhagat Singh College
Simran Chaddha, Dyal Singh College
Someshwar Sati, Kirorimal College
Vinita Chandra, Ramjas College
Yamini, Dyal Singh College

DCE COURSE

PAPER D1
AMERICAN LITERATURE
Semester 5

Course Statement

This course offers students an opportunity to study the American literary tradition as a tradition which is distinct from and almost a foil to the traditions which had developed in European countries especially in England. A selection of texts for this course therefore highlights some of the key tropes of mainstream America's self-perception such as Virgin Land the New World Democracy Manifest Destiny the Melting-Pot and Multiculturalism. At the same time there are specifically identified texts that draw the attention of students to cultural motifs which have either been erased brutally suppressed or marginalized (the neglected and obscured themes from the self-expression of the subaltern groups within American society) in the mainstream's pursuit of the fabled American Dream. A careful selection of writings by native Americans African Americans as well as texts by women and other sexual minorities of different social denominations seeks to reveal the dark underside of America's progress to modernity and its gradual emergence as the most powerful nation of the world.

Course Objectives

The course aims to

- acquaint students with the wide and varied literatures of America: literature written by writers of European particularly English descent reflecting the complex nature of the society that emerged after the whites settled in America in the 17th century
- include Utopian narrative transcendentalism and the pre- and post- Civil War literature of the 19th century
- introduce students to the African American experience both ante-bellum and post-bellum reflected in the diversity of literary texts from narratives of

slavery political speeches delivered by Martin Luther King Jr. and Malcolm X as well as the works of contemporary black woman writers
- familiarize students with native American literature which voices the angst of a people who were almost entirely wiped out by forced European settlements and
- include modern and contemporary American literature of the 20th century.

Course Content

Unit 1
James Fennimore Cooper *The Pioneers*

Unit 2
Toni Morrison *Beloved*

Unit 3
Arthur Miller *Death of a Salesman* (Penguin 1978).

Unit 4
Poetry
a) Walt Whitman 'O Captain! My Captain' in *Walt Whitman: Poetry and Prose* ed. Shira Wolosky (The Toby Press 2003) pp. 360-61).
b) Emily Dickinson 'Because I Could Not Stop for Death' in *The Poems of Emily Dickinson* ed. Ralph W. Franklin (Harvard UP 1998).
c) Allen Ginsberg 'A Supermarket in California' in *Selected Poems 1947-1995* (Penguin Books 2001) p. 59.
d) Langston Hughes (i) 'The Negro Speaks of Rivers'(ii) 'The South' (iii) 'Aunt Sue's Stories' in *The Weary Blues* (New York: Alfred A. Knopf 2015) pp. 33 36 39.
e) Joy Harjo (i) 'Perhaps the World Ends Here'(ii) 'I Give You Back' in *The Woman That I Am: The Literature and Culture of Contemporary Women of Color* ed. D. Soyini Madison (New York: St Martin's Press 1994) pp. 37-40.

Short Stories

f) Herman Melville 'Bartleby the Scrivener: A Story of Wall Street' (1853) (Createspace Independent Publishing Platform).
g) Flannery O' Connor 'Everything that Rises Must Converge' in *Everything that Rises Must Converge* (New York: Farrar Straus Giroux 1965).
h) Leslie Marmon Silko 'The Man to Send Rain Clouds' in *Nothing but the Truth: An Anthology of Native American Literature* ed. John L. Purdy and James Ruppert (New Jersey: Prentice Hall 2001) pp. 358-61.

Unit 5
Readings

a) 'Declaration of Independence' July 4 1776 in *For Liberty and Equality: The Life and Times of the Declaration* (OUP 2012) pp. 312) or 'Abraham Lincoln Gettysburg Speech' in *Gettysburg Speech and Other Writings* (Barnes &Noble 2013).
b) Ralph Waldo Emerson *Nature* (1836) (Boston: James Munroe and Company 1836 [2006]) pp. 5-9.
c) Martin Luther King Jr 'I have a dream' in *African American Literature* ed. Kieth Gilyard Anissa Wardi (New York: Penguin 2014) pp. 1007-11)
d) Malcom X Extracts from 'Ballot or Bullet' in *African American Literature* ed. Kieth Gilyard Anissa Wardi (New York: Penguin 2014) paras 9-40 pp. 1120-130.
e) Adrienne Rich 'When We Dead Awaken: Writing as Re-Vision' *College English* Vol. 34 No. 1 Women Writing and Teaching pp. 18-30.

Teaching Plan
Paper D1: American Literature

Week 1 -- Introduction to Paper 1: American Literature
Week 2 – Unit 1 -- Novel: Cooper *The Pioneers*
Week 3 – Unit 1 – Cooper (contd)
Week 4 – Unit 2 -- Novel: Morrison *Beloved*
Week 5 – Unit 2 – Morrison (contd)
Week 6 – Unit 3 -- Drama: Miller *Death of a Salesman*
Week 7 – Unit 3 –Miller (contd)
Week 8 – Unit 4 – Poetry:
(a) Whitman 'O Captain! My Captain'
(b) Dickinson 'Because I Could Not Stop for Death'
(c) Ginsberg 'A Supermarket in California'
Week 9 – Unit 4 – Poetry (contd):
(d) Langston Hughes (i) 'The Negro Speaks of Rivers' (ii) 'The South' (iii) 'Aunt Sue's Stories
(e) Harjo (i) 'Perhaps the World Ends Here' (ii) 'I Give You Back'
Week 10 -- Unit 4 -- Short Stories:
(a) Melville 'Bartleby the Scrivener: A Story of Wall Street'
(b) O' Connor 'Everything that Rises Must Converge'
(c) Silko 'The Man to Send Rain Clouds'

Week 11 – Unit 5 -- Prose Readings:
(a) Declaration of Independence' July 4 1776 or 'Abraham Lincoln Gettysburg Speech'
(b) Ralph Waldo Emerson *Nature*

Week 12 – Prose Readings (contd):

(c) Martin Luther King Jr 'I have a dream'

(d) Malcom X Extracts from 'Ballot or Bullet' (paras 9-40)

Week 13 – Prose Readings (contd):

(e) Adrienne Rich 'When We Dead Awaken: Writing as Re-Vision.'

Week 14 - Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

The New World
Democracy
Multiculturalism
American Dream
Native American literature
Transcendentalism
Pre- and Post-Civil War literature
African American experience
Slavery
Beat generation
Black woman writers
Civil rights movement

Sub-committee

Al Moohshina Muzzammil Zakir Husain College (Evening) (Coordinator)
Aneeta Rajendran Gargi College
Dhanajay Kapse Kirorimal College
N. A. Jacob Ramjas College.
Sandhya Devesan Nambiar Jesus and Mary College.

Course designed in Consultation with Dr Tapan Basu Department of English University of Delhi

PAPER D2
GRAPHIC NARRATIVES
Semester 5

Course Statement

The graphic novel has become a prominent form in literary culture today speaking to a variety of concerns spanning both the mass-market and countercultures. In each of its iterations the best graphic narratives work through the interdependence of art and text the mutual connections between illustration blank space size and writing. This course aims to introduce students to the form examining how artists/graphic novelists have used the medium to provide cultural commentary.

Course Objectives

This course aims to

- examine major graphic narratives as providing commentary on contemporary culture history and mythology
- explore visual art as extending translating and providing a new textual vocabulary to narrative including fictional and non-fictional narrative
- provide exposure to major genres within the field such as that of the mass-circulation superhero the fictionalized autobiography/memoir revisionist narratives of mythological or historical or biographical texts and that of fiction and
- provide tools for the exploration of form and genre that are sensitive to nuances of race gender caste ethnicity ableism and sexuality.

Course Content

Unit 1

Frank Miller *Batman: The Dark Knight Returns*(Delhi:Random House 1986 [2016]).

Unit 2

a) Durgabai Vyamand Srividya Natarajan*Bhimayana: Experiences of Untouchability* (Delhi: Navayana Press 2011)
b) S. S. Rege and Dilip Kadam (*Babasaheb Ambedkar: He Dared to Fight* Vol. 611 (Mumbai: Amar Chitra Katha 1979).

Unit 3

a) Amruta Patil *Kari* (Delhi: Harper Collins 2008)
b) Marjane Satrapi *Persepolis*: *The Story of a Childhood*(London:Pantheon 2004).

Unit 4

Art Spiegelman *The Complete Maus* (England: Penguin 2003).

Unit 5
Readings

a) Hillary Chute 'Comics as Literature? Reading Graphic Narrative' *PMLA* 123 (2): 452-65.
b) Karline McLain 'Introduction' in *India's Immortal Comic Books* (USA: Indiana UP 2009) pp. 1-23.
c) Scott McCloud *Understanding Comics: The Invisible Art* (USA: HarperCollins 1993) pp. 60-137.
d) Nina Mickwitz *Documentary Comics: Graphic Truth-telling in a Skeptical Age* (UK: Palgrave Macmillan 2016) pp. 1-28.
e) David K. Palmer 'The Tail That Wags the Dog: The Impact of Distribution on the Development and Direction of the American Comic Book Industry' in Casey Brienza and Paddy Johnston eds*Cultures of Comics Work*(UK: Palgrave Macmillan 2016) pp. 235-49.

Teaching Plan
Paper D2: Graphic Narratives

Week 1: Unit 1 – The Graphic Novel
Miller *Batman: The Dark Knight Returns*
Unit 5 -- Reading: Hillary Chute 'Comics as Literature? Reading Graphic Narrative'
Week 2: Unit 1 (contd)
Week 3: Unit 1 (contd)
Week 4: Unit 2 -- Graphic Narratives:

(a) Vyam and Natarajan *Bhimayana: Experiences of Untouchability*
(b) Rege and Kadam *Babasaheb Ambedkar: He Dared to Fight*

Week 5: Unit 2 (contd)
Week 6: Unit 2 (contd)
Week 7: Unit 3 -- Graphic Novels:
(a) Patil *Kari*
(b) Satrapi *Persepolis*: *The Story of a Childhood*

Week 8: Unit 3 (contd)
Week 9: Unit 3 (contd)
Week 10: Unit 4 -- Graphic Novels:
Spiegelman *The Complete Maus*

Week 11: Unit 4 (contd)
Week 12: Unit 4 (contd)
Week 13: Unit 5 – Readings:
(b) McLain 'Introduction' in *India's Immortal Comic Books*
(c) McCloud *Understanding Comics: The Invisible Art*

Week 14: Unit 5 – Readings:
(d) Mickwitz *Documentary Comics: Graphic Truth-telling in a Skeptical Age*
(e) Palmer 'The Tail That Wags the Dog: The Impact of Distribution on the Development and Direction of the American Comic Book Industry'

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Graphic narratives
Visual art
Forms and genres
Revisionist commentary
Culture
History and mythology

Sub-committee

Gorvika Rao Miranda House (Coordinator)
Amrita Singh Kamla Nehru College
Aneeta Rajendran Gargi College (Coordinator)
Rina Ramdev Sri Venkateswara College
Shraddha Adityavir Singh Zakir Husain College
Shweta Sachdeva Jha Miranda House

PAPER D3
INDIAN WRITING IN ENGLISH
Semester 5

Course Statement

Over the past two centuries and especially after the 1980s Indian writing in English has emerged as a major contribution to Indian—and global—literary production. A close analysis of some of the major works of Indian writing in English is crucial in any exploration of modern Indian subjectivities histories and politics.

Course Objectives

This course aims to

- introduce students to Indian English Literature and its major movements and figures through the selected literary texts across genres
- enable the students to place these texts within the discourse of post-coloniality and understand Indian literary productions in English in relation to the hegemonic processes of colonialism neo-colonialism nationalism and globalization and
- allow the students to situate this corpus within its various historical and ideological contexts and approach the study of Indian writing in English from the perspectives of multiple Indian subjectivities.

Course Content

Unit 1

Novel

Mukul Kesavan *Looking Through Glass* (1995)

Unit 2

Novel

Arundhati Roy *The God of Small Things* (1996)

Unit 3

Drama

a) Manjula Padmanabhan *Lights Out* (1984)
b) Mahesh Dattani *Tara* (1995)

Unit 4
Short Stories

a) Shashi Deshpande 'The Intrusion'
b) Salman Rushdie'The Prophet's Hair'
c) Rohinton Mistry'Swimming Lessons'

Poems

d) Kamala Das (i) 'An Introduction' (ii) 'My Grandmother's House'
e) Jayanta Mahapatra (i) 'Hunger' (ii) 'Grandfather'
f) Robin Ngangom (i) 'A Poem for My Mother' (ii) 'Native Land'

Unit 5
Readings

a) Raja Rao 'Foreword' to *Kanthapura* (New Delhi: OUP 1989) pp. v–vi.
b) Arvind Krishna Mehrotra'Towards a History of Indian Literature in English' in *Partial Recall: Essays on Literature and Literary History* (New Delhi: Permanent Black 2012) pp. 196-235.
c) Meenakshi Mukherjee 'Epic and Novel in India' in *The Novel* Vol. 1 ed. Franco Moretti (Princeton NJ: Princeton University Press 2006) pp. 596-631.

d) Ulka Anjaria'Introduction: Literary Pasts Presents and Futures' in *A History of the Indian Novel in English* ed. Ulka Anjaria (New Delhi: OUP 2015) pp. 1-30.
e) Rajeev S. Patke'Poetry since Independence' in *An Illustrated History Of Indian Literature in English* ed. Arvind Krishna Mehrotra (New Delhi: Permanent Black 2003) pp. 243-75.

Teaching Plan
Paper D3: Indian Writing in English

Week 1 -- Introduction to Paper D3: Indian Writing in English
Week 2 – Unit 1 -- Novel: Kesavan *Looking Through Glass*
Week 3 – Kesavan (contd)
Week 4 – Unit 2 -- Novel: Roy *The God of Small Things*
Week 5 – Roy (contd)
Week 6 – Unit 3 -- Drama: Padmanabhan *Lights Out*
Week 7 – Padmanabhan (contd)
Week 8– Unit 3 -- Drama: Dattani *Tara*
Week 9 – Dattani (contd)
Week 10 – Unit 4 -- Short Stories:
(a) Deshpande 'The Intrusion'
(b) Rushdie 'The Prophet's Hair'
(c) Mistry 'Swimming Lessons'
Week 11 – Unit 4 (contd) – Poems:
(a) Das (i)'An Introduction' (ii) 'My Grandmother's House'
(b) Mahapatra (i) 'Hunger' (ii) 'Grandfather'
(c) Ngangom (i) 'A Poem for My Mother' (ii) 'Native Land'
Week 12- Unit 5 – Readings:
(a) Rao 'Foreword' to *Kanthapura*
(b) Mehrotra 'Towards a History of Indian Literature'
Week 13 – Readings (contd):
(a) Mukherjee 'Epic and Novel in India
(b) Anjaria 'Introduction: Literary Pasts Presents and Futures'
(c) Patke 'Poetry since Independence'
Week 14 -- Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions

2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Postcolonial writing
Nationalism
Tradition
Modernity
Native imagery

Sub-committee

Karuna Rajeev Lady Shri Ram College (Coordinator)
Someshwar Sati Kirori Mal College
Dhananjay Kapse Kirori Mal College
Sherina Joshi Deshbandhu College
Yamini Dyal Singh College

PAPER D4
INTERROGATING QUEERNESS
Semester 5

Course Statement

This paper examines interrogations of the heteronorm across cultures and geographies as seen in representative texts in western and south Asian literary traditions. Themes of the body desire sexuality and gender are explored to understand their constructedness and historical specificity the heteronorm is shown to coexist alongside other positions over various arcs in time. Emotive constructs such as love and romance and sociological ones like family and kinship are examined as concepts embedded in power relations and history culture rather than 'nature'. The paper uses positions that emerge in queer theory to understand how power relations that privilege heteropatriarchal reproduction use violence erasure and invisibility to create particular masculinities and femininities as normative.

Course objectives

This paper aims to

- enable students to examine several key themes including love desire identity gender masculinity femininity family/kinship deviance sexuality power normativities and resistance to these normatives
- help students follow the concept of queerness as an interrogation of heteronormativity through its representation in diverse cultural historical and geographic landscapes to examine how normative structures are constituted and subverted and
- use materials from diverse creative traditions including mainstream and non-marginal texts in mythology fiction poetry to familiarise students with the idea that normative structures of desire are themselves heterogeneous social constructs that change over time.

Course Content

Unit 1

a) Sappho (i) Select lyrics 'Hymn to Aphrodite'(ii) select lyric fragments'I Have Not Had One Word From Her' (iii)'He seems an equal of the gods' in *If not Winter: Fragments of Sappho* ed. and trans. Anne Carson(USA: Little Brown 2003).
b) Plato (i) The Speech of Phaedrus (ii) The Speech of Pausanias (iii) The Speech of Aristophanes (iv) The Dialogue of Socrates and Diotima from 'Symposium' in the *Columbia Anthology of Gay Literature*ed. Byrne R. S. Fone (USA 2001) pp. 26-38.
c) The Bible (i) excerpts from the Book of Ruth 1: 1-22 2: 1-23 3: 1-18 4: 1-22 (ii) The Old Testament The Story of Sodom: Genesis 18-19 (iii) The Holiness Code (iv) Leviticus 18:22 (v) Leviticus 20:13 (vi) The New Testament: From the Epistles of St. Paul (vii) Romans 1:26-27 (viii) 1 Corinthians 6:9-10.
d) William Shakespeare Sonnets 20 80 87 121 in*The Complete Sonnets and Poems* ed. Colin Burrow (UK: OUP 2002).

Unit 2

a) Mahabharata Udyoga Parva CLXXXVIII-CXCV Shikhandin trans. Kisari Mohan Ganguly (Delhi: Munshiram Manoharlal 1883-96) pp. 358-72.
b) *Bhagavata Purana Skanda Purana Shiva Purana* on Shiva and Vishnu Sumedha and Somavan Birth of Kartikeya Birth of Ganesha) in *Same Sex Love in India* eds Ruth Vanita and Salim Kidwai (India: Macmillan 2000) pp. 69-84.
c) Madho Lal Hussein Kafis 2 3 5 10 13 trans. Naveed Alam in *Verses of a Lowly Fakir* (India: Penguin) pp. 4-17.
d) Rangeen Insha Jan (i) 'My Heart's Desire' (ii) 'I Spent All Night' (iii) 'I'll Give

My Life for You' in *When Men Speak as Women: Vocal Masquerade in Indo-Muslim Poetry* ed. and trans. Carla Petievich OUP: New Delhi 2007)p. 293 p. 321 pp. 333-34.

Unit 3

James Baldwin *Giovanni's Room* (Penguin 2007 [1956]).

Unit 4

Suniti Namjoshi *The Mothers of Maya Diip* (UK: The Women's Press 1989).

Unit 5
Readings

a) Gloria Anzaldua 'Gestures of the Body' *Light in the Dark/Luz en lo Oscuro: Rewriting Identity Spirituality Reality* trans. and ed. Ana Louise Keating (USA: Duke UP 2015) pp.1-9.
b) Judith Butler 'Critically Queer' *GLQ* 1:1 (1993) pp. 17-32.
c) Michel Foucault 'The Deployment of Sexuality: Method' trans. Robert Hurley in *The History of Sexuality* Vol. 1 (NY: Pantheon 1978) pp. 92-103.
d) Judith Halberstam *Female Masculinity* (USA: Duke UP 1998) pp. 1-44.
e) Audre Lorde 'The Uses of the Erotic: The Erotic as Power' in *Sister/Outsider* (CA: Crossing Press 1984) pp. 53-59.

Teaching Plan
Paper D4: Interrogating Queerness

Week 1: Unit 1:
(a) Sappho (i) Select lyrics 'Hymn to Aphrodite' (ii) select lyric fragments 'I Have Not Had One Word From Her' (iii) 'He seems an equal of the gods'

Week 2: Unit 1 (contd):
(b) Plato (i) The Speech of Phaedrus (ii) The Speech of Pausanias (iii) The Speech of Aristophanes(iv) The Dialogue of Socrates and Diotima from 'Symposium'

Week 3: Unit 1 (contd):
(c) The Bible (i) excerpts from the Book of Ruth (ii) The Old Testament The Story of Sodom (iii) The Holiness Code (iv) Leviticus 18:22 (v) Leviticus 20:13 (vi) The New Testament: From the Epistles of St. Paul (vii) Romans 1:26-27 (viii) 1Corinthians 6:9-10.

Week 4: Unit 1(contd):

(d) Shakespeare Sonnets 20 80 87 121

Week 5: Unit 2:

(a) Mahabharata Udyoga Parva CLXXXVIII-CXCV Shikhandin

(b) *Bhagavata Purana Skanda Purana Shiva Purana* on Shiva and Vishnu Sumedha and Somavan Birth of Kartikeya Birth of Ganesha

Week 6: Unit 2 (contd):

(c) Hussein Kafis 2 3 5 10 13

Week 7: Unit 2 (contd):

(d) Rangeen Insha Jan (i) 'My Heart's Desire' (ii) 'I Spent All Night' (iii) 'I'll Give My Life for You'

Week 8: Unit 3 --Baldwin *Giovanni's Room*

Week 9: Baldwin (contd)

Week 10: Baldwin (contd)

Unit 4 -- Namjoshi *The Mothers of Maya Diip*

Week 11: Namjoshi (contd)

Week 12: Namjoshi (contd)

Week 13: Unit 5 –Readings:

(a) Anzaldua 'Gestures of the Body'

(b) Butler 'Critically Queer'

Week 14: Unit 5 (contd):

(c) Foucault 'The Deployment of Sexuality: Method'

(d) Halberstam *Female Masculinity*

(e) Lorde 'The Uses of the Erotic: The Erotic as Power'

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Heteronorm
Desire
Sexuality
Queerness
Queer theory
Normative masculinities and femininities

Sub-committee

Aneeta Rajendran Gargi College (Coordinator)
Brati Biswas Dyal Singh College
Karen Gabriel St Stephen's College
Rajendra Parihar Ramjas College
Wafa Hamid Lady Shriram College
Shweta Sachdeva Jha Miranda House

PAPER D5
LITERARY CRITICISM AND THEORY– 1
Semester 5

Course Statement

This is the first of two papers dealing with literary criticism and theory as a discipline within literary studies in the European tradition. It is crucial to the understanding of the interface between the history of ideas and the literary texts that are studied in the Core Curriculum. The paper covers a large historical span from the Classical Greco-Roman tradition to New Criticism and Russian Formalism in the twentieth century. In the process it traverses key moments in the emergence of aesthetic theory in Europe including British Neoclassicism German Romanticism and the Nineteenth Century. The paper aims to introduce students to important excerpts from a wide range of literary theorists and philosophers whose works intervene in specific ways with the idea of literary representation and aesthetic theory. Each unit explores a particular set of inter-related themes raising various connections between the theoretical questions.

Course Objectives

This course aims to

- expose students to the various theories of art and representation and critical approaches that emerged in Europe throughout centuries

- to examine the evolution of various theoretical and aesthetic concepts across space and time and pay close attention to the method of argument and establishment of concepts and
- enable students to discern the connections between the theoretical formulations in this paper which are seminal to the understanding of literary texts.

Course Content

Unit 1

a) Plato From *Phaedrus* trans. Robin Waterfield (New York: OUP 2002) pp. 68-75.
b) Longinus From 'On the Sublime' in *The Norton Anthology of Theory and Criticism* ed. Vincent B. Leitch (New York: W. W. Norton & Co. 2001) pp. 138-54.
c) Plotinus 'On the Intellectual Beauty' trans. Stephen MacKenna from the fifth Ennead in Plotinus: The Six Enneads (UK: Penguin Books 1991) pp. 410-24.

Unit 2

a) David Hume 'Of the Standard of Taste' from 'Four Dissertations' in*The Norton Anthology of Theory and Criticism* ed. Vincent Leitch (New York: W. W. Norton & Co. 2001) pp. 486-99.
b) Edmund Burke 'Introduction on Taste' from Part II and Part III in *A Philosophical Enquiry into the Origin of Our Ideas of the Sublime and Beautiful* (UK: OUP 1990) pp. 11-26 53-71 83-105.

Unit 3

a) Immanuel Kant 'Analytic of the Beautiful' trans. Paul Guyer in*The Critique of Judgment* (Cambridge: Cambridge University Press 2000) 89-127.
b) Friedrich Schiller Letters 2 6 and 9trans. Reginald Snell in *Letters on the Aesthetic Education of Man* (UK: Dover Publications 2004) pp. 46-50 69-83 93-100.

Unit 4

a) G. W. F. Hegel (i) 'Work of Art as Product of Human Activity' (ii) 'The Kantian Philosophy' (iii) 'Imagination Genius and Inspiration'trans. T. M. Knox in *Aesthetics: Lectures on Fine Art* Vol. 1(Oxford: Clarendon Press 1988) pp. 25-32 56-61 281-88.
b) Friedrich Nietzsche 'What is the Meaning of Ascetic Ideals' Book III Sections 1–6 trans. Walter Kaufmann and John Hollingdale in *On the Genealogy of Morals* (New York: Vintage Books 1967) pp. 1-6.

Unit 5

a) Mikhail Bakhtin From ‘Forms of Time and of the Chronotope in the Novel’trans. Caryl Emerson Michael Holquist in *The Dialogic Imagination: Four Essays* (Texas: University of Texas Press 1981) pp. 84-110 243-58.
b) Cleanth Brooks (i) ‘The Language of Paradox’ and (ii) ‘Heresy of Paraphrase’ in *The Well-Wrought Urn* (New York: Harvest Books 1947) pp. 12-29 185-205.

Teaching Plan
Paper D5: Literary Criticism and Theory - 1

Week 1:Introduction to Paper 5: Literary Theory and Criticism - 1
Week 2: Unit 1 -- Greek theory: Plato From *Phaedrus* Plotinus ‘On the Intellectual Beauty’
Week 3: Unit 1 -- Roman theory: Longinus From ‘On the Sublime’
Week 4: Unit 2 -- Introduction to Neoclassical and Augustan Critical Theories.
Week 5: Unit 2 -- Hume ‘Of the Standard of Taste’
Week 6: Unit 2 – Burke ‘Introduction on Taste’
Week 7: Unit 3 -- Introduction to German enlightenment.
Week 8: Unit 3 – Kant ‘Analytic of the Beautiful’
Week 9: Unit 3 – Schiller Letters 2 6 and 9
Week 10: Introduction to 19th Century concepts of art and literature.
Week 11: Unit 4 – Hegel (i) ‘Work of Art as Product of Human Activity’ (ii) ‘The Kantian Philosophy’ (iii) ‘Imagination Genius and Inspiration’
Week 12: Unit 4 – Nietzsche ‘What is the Meaning of Ascetic Ideals’ Book III Sections 1–6
Week 13: New Criticism in the 20th Century: Cleanth Brooks (i) ‘The Language of Paradox’ and (ii) ‘Heresy of Paraphrase’
Week 14: Unit 5 -- Formalism and its critique: Mikhail Bakhtin ‘Forms of Time and of the Chronotope in the Novel’

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions

2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Speech vs Writing
Sublime
Aesthetics
Taste
Beautiful
Narrative
Poetics

Sub-committee

Madhvi Zutshi SGTB Khalsa College (Coordinator)
N. A. Jacob Ramjas College
Rudrashish Chakraborty Kirori Mal College (Coordinator)
Saikat Ghosh SGTB Khalsa College
Advisors:
Dr. Rimli Bhattacharya Dept. of English
Prof. Shaswati Mazumdar Dept. of Germanic and Romance Studies

PAPER D6
LITERATURE FOR CHILDREN AND YOUNG ADULTS
Semester 5

Course Statement

This paper explores the many forms and genres found in writing for children and young adults. The texts in this course cover a vast range from picture books to writings for children and young adults. Through the readings students can explore the construction of childhood as well as the emergence of children's literature as a genre. The course explores the cultural importance of genres aimed at young readership and simultaneously engages with theoretical frameworks by which such texts can be read.

Course Objectives

This course aims to

- help students trace the emergence of the genre termed Children's Fiction and link it to the emergence of other genres as print culture has grown
- familiarize students with the idea of visual literacy illustrations etc. and their application and use in children's picture books and
- facilitate an engagement with the concept of Young Adult Literature and issues associated with it.

Course Content

Unit 1

a) Antoine de Saint-Exupéry *Little Prince*(New Delhi: Pigeon Books 2008).
b) Oliver Jeffers *Heart in a Bottle* (New York: Harper Collins 2011).
c) bell hooks and Chris Raschka *Happy to be Nappy*(New York: Jump at the Sun 2017).
d) Mahashweta Devi *The Why Why Girl*(New Delhi: Tulika Publishers 2012).

Unit 2

a) Upendra Kishore Roychowdhury *GoopyGyneBagha* Byne (New Delhi: Puffin Books 2004) pp. 3-27
b) Sulaiman Ahmed *Amar Ayyar:King of Tricksters* Chapters 1-6 51 67 68(New Delhi: Hachette India 2012).
c) Paro Anand *No Guns at My Son's Funeral*(New Delhi: India Ink 2005).

Unit 3

Mark Haddon *The Curious Incident of the Dog in the Night-Time* (London: Vintage 2012).

Unit 4

M.T. Anderson *Feed* (Somerville: Candlewick Press 2002).

Unit 5
Readings

a) Molly Bang 'Building the Emotional Content of Pictures in *Picture This: How Pictures Work* (San Francisco: Chronicle Books 2018) pp. 1-50 with illustrations.
b) Perry Nodelman 'Defining Children's Literature' in *The Hidden Adult: Defining Children's Literature* (Baltimore: John Hopkins University Press 2008) pp. 133-37.

c) John Holt ‘Escape from Childhood’. Available online at https://canopy.uc.edu/bbcswebdav/pid-14529539-dt-content-rid-39705338_1/courses/16SS_EDST1001005/16SS_EDST1001005_ImportedContent_20151117021819/Course%20Readings/Escape%20from%20Childhood.pdf

d) Rachel Falconer ‘Young Adult Fiction and the Crossover Phenomena’ in *The Routledge Companion to Children's Literature* ed. David Rudd (New York: Routledge 2010) pp. 87-97.

Teaching Plan
Paper D6: Literature for Children and Young Adults

Week 1 – Introduction to Paper 6: Literature for Children and Young Adults
Unit 5 – Nodleman ‘Defining Children’s Literature’
Holt ‘Escape from Childhood’
Week 2 – Unit 1 – de Saint-Exupéry *The Little Prince*
Week 3 – Unit 5 – Bang ‘Building the Emotional Content of Pictures
Unit 1 – Jeffers *Heart in a Bottle*
hooks and Raschka *Happy to be Nappy*
Week 4 – Unit 1 – Mahashweta Devi *The Why Why Girl*
Week 5 – Unit 5 – Falconer ‘Young Adult Fiction and the Crossover Phonomena’
Unit 2 – Roychowdhury *Goopy Gyne Bagha Byne*
Ahmed *Amar Ayyar: King of Tricksters* Anand *No Guns at My Son’s Funeral*
Week 6 – Unit 2 (contd)
Week 7 – Unit 2 (contd)
Week 8 – Unit 3 – Haddon *The Curious Incident of the Dog in the Night-Time*
Week 9 – Haddon (contd)
Week 10 – Haddon (contd)
Week 11 – Unit 4 – Anderson *Feed*
Week 12 – Anderson (contd)
Week 13 – Anderson (contd)
Week 14 – Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions

2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Children's literature
Picture books
Young adult fiction
Childhood
Visual literacy
Nonsense verse
Readership

Sub-commitee

Shweta Sachdeva Jha Miranda House College (Coordinator)
Sanam Khanna Kamala Nehru College
Neha Singh Kamala Nehru College
Nidhi Bhandari Kamala Nehru College
Nitya Dutta Sri Venkateswara College
Nivedita Sen Hansraj College

PAPER D7
LITERATURE AND MEDIALITY
Semester 5

Course Statement

This paper explores how literature inhabits and intersects with diverse media ranging from oral and scribal cultures to graphic images and digital formats. It aims to introduce students to the mediatedness of all literary expression and to understand what is at stake in acknowledging that each medium constitutes the literary in specific ways. Additionally the paper will also examine the idea of inter-mediality as well as newer notions of texts and authorship in a digital age.

Course Objectives

This course aims to

- examine different media and explore how each medium contains a set of possibilities and limits that shape and constitute that which can be communicated
- introduce debates about the idea of mediation and how the literary gets articulated both within and at the intersection of different media and
- study how digital technology is altering the very nature of the literary object as well as refashioning the methodologies and function of literary criticism.

Course Content

Unit 1

Literature and the History of the Book

a) Elizabeth Eisenstein 'Some Features of Print Culture' in *The Printing Revolution in Early Modern Europe* 2nd edn (Cambridge University Press 2005) 46-70.
b) Robert Darnton 'What is the history of books?' *Daedalus* Vol. 111.3 (1982): 65-83.
c) Margreta De Grazia and Peter Stallybrass 'The Materiality of the Shakespearean Text' *Shakespeare Quarterly* Vol. 44.3 (1993): 255-83.
d) Abhijit Gupta 'The History of the Book in the Indian Subcontinent' in *The Oxford Companion to the Book* eds M. S. J Suarez and H. R. Woudhuysen (Oxford: Oxford University Press 2012).

Unit 2

Literature and Orality/Music

a) Plato from *Phaedrus*trans. Robin Waterfield (New York: OUP 2002) pp. 68-75.

b) Walter Ong from 'Orality and Literacy: The Technologizing of the Word' (Routledge 2002) pp. 1-35.

c) Theodor Adorno 'On Popular Music' *Studies in Philosophy and Social Science* 9:17 (1941).

d) George Meredith 'The Lark Ascending' (poem).

e) Ralph Vaughan Williams 'The Lark Ascending' (musical composition).

Unit 3

Literature and the Visual Image

a) G. E. Lessing from *Laocoön: An Essay Upon the Limits of Painting and Poetry* Chapters 1 2 3 16 17 18 (Dover Publications 2005) pp. 1-19 91-117.

b) W. J. T. Mitchell 'What Is an Image?'*New Literary History* Vol. 15 No. 3.

c) Murray Krieger 'The Ekphrastic Principle and the Still Movement of Poetry or *Laocoön*Revisited' in *The Play and Place of Criticism* (Baltimore: Johns Hopkins University Press 1967).

d) John Berger from *Ways of Seeing* Chapter 7 (Penguin Classics 2008) pp. 129-55.

Unit 4

Literature and the Digital

a) Adam Hammond from *Literature in the Digital Age.*

b) Franco Moretti*Graphs. Maps. Trees* (Verso 2005).

c) N. Katherine Hayles 'Intermediation from Page to Screen' in *Electronic Literature: New Horizons for the Literary* (University of Notre Dame Press 2008) pp. 43-86.

Unit 5

Readings

a) W. J. T. Mitchell from *Picture Theory*.

b) Theodor Adorno from *Philosophy of New Music*.

c) Donna Haraway 'A Cyborg Manifesto: Science Technology and Socialist-Feminism in the Late Twentieth Century' in *Simians Cyborgs and Women: The Reinvention of Nature* (Routledge 1991) pp. 149-81.

d) N Katherine Hayles from *Writing Machines.*

Teaching Plan
Paper 7: Literature And Mediality

Week 1 – Introduction -- History of the BookUnit 1:
(a) Eisenstien 'Some Features of Print Culture'
Week 2 -- History of the Book (contd):
(b) Darnton 'What is the history of books?'
(c) Grazia and Stallybrass 'The Materiality of the Shakespearean Text'
Week 3 -- History of the Book (contd):
(d) Gupta 'The History of the Book in the Indian Subcontinent'
Week 4 -- Literature and Orality:
(a) Plato from *Phaedrus*
Week 5 -- Literature and Orality (contd):
(b) Ong from 'Orality and Literacy: The Technologizing of the Word'
Week 6 -- Literature and Music:
(c) Adorno 'On Popular Music'

Week 7 -- Literature and the Visual Image:
(a) Lessing from *Laocoön: An Essay Upon the Limits of Painting and Poetry*
Week 8 -- Literature and the Visual Image (contd):
(b) Mitchell 'What Is an Image?'
Week 9 -- Literature and the Visual Image (contd):
(c) Kreiger 'The Ekphrastic Principle and the Still Movement of Poetry or *Laocoön*Revisited'
Week 10 -- Literature and the Digital:
(a) Hammond from *Literature in the Digital Age*
Week 11 -- Literature and the Digital (contd):
(b) Moretti*Graphs. Maps. Trees*
Week 12 -- Literature and the Digital (contd):
(c) Hayles from *Writing Machines*
Week 13 --Readings:
(a) Mitchell from *Picture Theory*
(b) Adorno from *Philosophy of New Music*
(c) Donna Haraway 'A Cyborg Manifesto: Science Technology and Socialist-Feminism in the Late Twentieth Century'
(d) Hayles from *Writing Machines*
Week 14 -- Readings (contd)

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Literature
Media
Book history
Orality
Digital
Music

Sub-committee

Shraddha Singh Zakir Husain Delhi College (Coordinator)
N. A. Jacob Ramjas College
Madhumita Chakraborty Zakir Husain Delhi College (E)
Saikat Ghosh SGTB Khalsa College
Shubhra Ray Zakir Husain Delhi College (E)

PAPER D8
LITERATURES OF DIASPORA
Semester 5

Course Statement

This paper intends to introduce to the students a preliminary view of diasporic literatures. The concepts of identity multiculturalism assimilation transnationalism transculturalism homeland and host land migration exile refugee expatriation etc are critically examined. The chosen themes and concepts will be explicated from a multiple range of genres such as memoir/autobiography novels plays short stories poetry and prose. The course is divided into five units. The course content and objectives are outlined below.

Course Objectives

This course aims to

- provide students with preliminary knowledge on the intrinsic connection between literature and diaspora
- help them acquire a set of basic skills in literary communication narration and explication of diasporic practises and processes
- enable an appreciation of the global intersectionalities stemming out of increased migration and cross cultural living culminating into diasporic practices
- inculcate in students the ability to read and understand various literary genres of diaspora
- analyse the writings of diverse authors representing world's major diasporic communities and
- help students decipher the literary features and push and pull factors of Jewish South-Asian American Chicano Armenian Fiji British Canadian Gulf Malaysian European Philippino and Chinese diasporic writings.

Course Content

Unit 1
Memoir/Autobiography

Maxine Hong Kingston *The Woman Warrior* (USA: Knopf Publishers 1976).

Unit 2
Novel

M. G. Vassanji *The In-Between World of Vikram Lall* (Toronto: Doubleday Canada 2003).

Unit 3
Drama

a) Hanif Kureishi *My Beautiful Laundrette*(London: Faber and Faber 1986).
b) Uma Parameswaran *Rootless but Green Are the Boulevard Trees* (Toronto: Tsar Publishers 1987).

Unit 4
Short Stories

a) Bernard Malamud 'The Jewbird' *The Idiots First* (New York: Farrar Straus & Giroux 1963).
b) K. S. Maniam 'Haunting The Tiger' in *Story-Wallah: A Celebration of South Asian Fiction* ed. Shyam Selvadurai (Toronto: Thomas Allen Publishers 2004).
c) Romesh Gunesekera 'Captives' in *Story-Wallah: A Celebration of South Asian Fiction* ed. Shyam Selvadurai (Toronto: Thomas Allen Publishers 2004).
d) Sophie Judah 'Hannah and Benjamin' in *Dropped From Heaven* (Knoph Doubleday Publishing Group 2007).

Poetry

a) Shirley Geok-lin Lim 'Learning to Love America' in *What the Fortune Teller Didn't Say* (New Mexico: West End Press 1998).
b) Eugene Gloria 'Milkfish' in *Drivers at the Short-Time Motel* (USA: Penguin 2000).
c) Jimmy Santiago Baca 'Immigrants in Our Own Land' in *Immigrants in Our Own Land* (New Directions Publishing Corporation 1990).

Unit 5
Readings

a) Vijay Mishra 'Introduction: The Diasporic Imaginary' in *The Literature of the*

Indian Diaspora: Theorising The Diasporic Imaginary (New York: Routledge 2007).

b) Elif Shafak 'Cinnamon' in The *Bastard of Istanbul* (USA: Viking Penguin 2007).

c) Deepak Unnikrishnan *Temporary People* Chapters 1 and 2 (New York: Restless Books 2017).

d) Caryl Phillips 'Somewhere In England' in *Crossing The River* (London: Random House 1993).

e) Paul Gilroy 'The Black Atlantic as a Counterculture of Modernity' *The Black Atlantic: Modernity and Double Consciousness* (London: Verso 1993).

Background Topics

- Hyphenated identities
- Multiculturalisms—melting pot mosaic salad bowl etc.
- Transnationalism and transculturalism
- Memory/nostalgia
- Push and pull factors
- Hybridity assimilation and dual consciousness
- Notions of homeland and host/new/alien land

Teaching Plan
Paper D8: Literatures of Diaspora

Week 1 – Introduction to Paper D8: Literatures of Diaspora
Week 2 – Unit 1 -- Memoir/Autobiography:
Kingston *The Woman Warrior*
Week 3 – Kingston (contd)
Week 4 – Unit 2 -- Novel:
Vassanji *The In-Between World of Vikram Lall*
Week 5 – Vassanji (contd)
Week 6– Unit 3 – Drama:
Kureishi *My Beautiful Laundrette*
Week 7– Kureishi (contd)
Week 8 – Unit 3 – Drama (contd):
Parameswaran *Rootless but Green Are the Boulevard Trees*
Week 9 – Unit 4 -- Short Stories:
(a) Malamud 'The Jewbird'
(b) Maniam 'Haunting The Tiger'
Week 10 – Unit 4 - Short Stories (contd):
(c) Gunesekera 'Captives'
(d) Judah 'Hannah and Benjamin'
Week 11 – Unit 4 – Poetry (contd):
(e) Shirley Geok-lin Lim 'Learning to Love America'
(f) Gloria 'Milkfish'
(g) Baca 'Immigrants in Our Own Land'

Week 12 – Unit 5 -- Prose Readings:

(a) Mishra 'Introduction: The Diasporic Imaginary'

(b) Shafak 'Cinnamon' in The Bastard of Istanbul

Week 13 – Unit 5 -- Prose Readings (contd):

(c) Deepak Unnikrishnan Temporary People

(d) Phillips 'Somewhere in England' in Crossing The River

(e) Gilroy 'The Black Atlantic as a Counterculture of Modernity.'

Week 14 -- Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Hyphenated identities
Multiculturalisms
Melting pot
Mosaic
Salad bowl etc.
Transnationalism
Transculturalism
Memory/nostalgia
Push and pull factors
Hybridity
Assimilation and
Dual consciousness
Homeland
Host/new/alien land

Sub-committee

B. R. Alamelu Indraprastha College for Women (Coordinator)
Al Moohshina Muzzammil Zakir Husain Delhi College (Evening)
Dhananjay Kapse Kirori Mal College
Mukul Chaturvedi Zakir Husain Delhi College (Morning)
Aneeta Rajendran Gargi College
Chaity Das Kalindi College

PAPER D9
MODERN INDIAN WRITING IN ENGLISH TRANSLATION
Semester 5

Course Statement

Striving to transcend a nativist rejection of Indian writing in English and a Rushdie-esque denial of the strength and value of Indian writing in languages other than English the need of the hour is to study the varied contributions of modern Indian writing through their translations into English free from the anxiety ***or*** hegemony of authenticity.

Course Objectives

This paper aims to

- give students a glimpse of the vast diversity of modern Indian writing in *bhasha* traditions
- show students the polyphonic tumultous richness of the 19th and 20th centuries from peasant life in colonial India in Fakir Mohan Senapati's novel to the mythical reality of O.V. Vijayan's novel from the reworking of a Mahabharata story in Girish Karnad's play to the myriad life-worlds of the poems and stories and
- encourage through the carefully selected poems stories and prose selections a deeper engagement with and a nuanced discussion of issues of history memory caste gender and resistance.

Course Content

Unit 1
Novel

Fakir Mohan Senapati *Six Acres and a Third* trans. Rabi Shankar Mishra Satya P. Mohanty Jatindra K. Nayak and Paul St-Pierre (Penguin 2006).

Unit 2
Novel

O. V. Vijayan *The Legends of Khasak* translated by the author (Penguin 2008).

Unit 3
Drama

Girish Karnad *The Fire and the Rain*translated by the author (OUP 2004).

Unit 4
Short Stories

a) Premchand 'Kafan' (The Shroud) trans. M.Asaduddin.
b) Perumal Murugan 'The Well' trans. N. Kalyan Raman.
c) Arupa Patangia Kalita 'Doiboki's Day' trans. Bonita Baruah.

Poems

a) Rabindranath Tagore (i) 'Where the mind is without fear trans. William Radice (ii) 'It hasn't rained in my heart' trans. Fakrul Alam.
b) G. M. Muktibodh 'Brahmarakshas' trans. Nikhil Govind.
c) Thangjam Ibopishak (i) 'The Land of the Half-Humans' (ii) 'I want to be killed by an Indian Bullet' trans. Robin S. Ngangom.

Unit 5
Readings

a) Rabindranath Tagore 'Nationalism in India' in *Nationalism* (Delhi: Penguin Books 2009) pp. 63-83.
b) U. R. Ananthamurthy 'Being a Writer in India' in *Tender Ironies* ed. Dilip Chitre et al. pp 127-46
c) Namvar Singh 'Decolonizing the Indian Mind' *Indian Literature* Vol. 35 No. 5 (151) (Sept.-Oct. 1992) pp. 145-56.
d) Vinay Dharwadker 'Some Contexts of Modern Indian Poetry' *Chicago Review* 38 (1992): 218-31.
e) Aparna Dharwadker 'Modern Indian Theatre' in *Routledge Handbook of Asian Theatre* ed. Siyuan Liu (London: Routledge 2016) pp. 243-67.

Teaching Plan

Paper D9: Modern Indian Writing In English Translation

Week 1 -- Introduction to Paper D9: Modern Indian Writing In English Translation

Week 2 – Unit 1 -- Novel:
Senapati *Six Acres and a Third*

Week 3 – Senapati (contd)

Week 4 – Unit 2 -- Novel:
Vijayan *The Legends of Khasak*

Week 5 – Vijayan (contd)

Week 6 – Unit 3 -- Drama:
Karnad *The Fire and the Rain*

Week 7 – Unit 4 -- Short Stories:
(a) Premchand 'Kafan'
(b) Murugan 'The Well'
(c) Kalita 'Doiboki's Day'

Week 8 – Unit 4 -- Poems:
(a) Tagore 'Where the mind is without fear' 'It hasn't rained in my heart'
(b) Muktibodh 'Brahmarakshas'

Week 9 – Unit 4 – Poems (contd):
(c) Ibopishak 'The Land of the Half-Humans' 'I want to be killed by an Indian bullet'

Week 10 --Unit 5 -- Prose Readings:
(a) Tagore 'Nationalism in India'

Week 11 – Unit 5 -- Prose Readings (contd):
(b) Ananthamurthy 'Being a Writer in India'

Week 12 – Unit 5 -- Prose Readings (contd):
(c) Singh 'Decolonizing the Indian Mind'

Week 13 – Unit 5 -- Prose Readings (contd):
(d) Dharwadker 'Some Contexts of Modern Indian Poetry'

Week 14 --Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions

2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Colonialism
Post-colonial
Decolonization
Translation
History
Memory
Caste
Class
Gender
Resistance

Sub-committee

Yamini Dayal Singh College (Coordinator)
Dhananjay Kapse Kirori Mal College
Sheuli Chowdhury Kamla Nehru College
Shweta Sachdeva Jha Miranda House
Someshwar Sati Kirori Mal College

PAPER D10
NINETEENTH CENTURY EUROPEAN REALISM
Semester 5

Course Statement

The rise of the novel as a dominant and popular literary genre in nineteenth-century Europe parallels the dominance of positivism and empiricism in the sciences the cycle of political and industrial revolutions the emergence of mass publishing and the advancement of ideological grand-narratives. While students acquaint themselves with the nineteenth-century English novel in the Core curriculum their perspective is enlarged and reflection is deepened through a comparative engagement with the development of different trajectories in the continental European novels primarily in France and Russia wherein the widespread popularity of novels occasioned a profound cultural debate on the value of a new aesthetic realism. This paper involves a study of the most representative and significant French and Russian novels of the crucial period between 1835 and 1870 when realism had dominated the sphere of aesthetic representation.

Course Objectives

This course aims to

- acquaint the student with realism as an historically and culturally specific mode of representation obtainable from the study of novels in nineteenth-century Europe
- allow the student an opportunity to see critical connections between Nineteenth-Century European Aesthetics and epistemological and political debates around reality and historical change and
- offer a wider comparatist perspective on the emergence of the Novel as dominant genre of literary expression in Nineteenth-Century Europe.

Course Content

Unit 1

Honoré de Balzac *Old Man Goriot* (1835) trans. Olivia McCannon (UK: Penguin Classics 2011).

Unit 2

Nikolai Gogol *Dead Souls* (1842) trans. Robert A. Maguire (UK: Penguin Classics 2004).

Unit 3

Gustave Flaubert *Madame Bovary* (1856) trans. Geoffrey Wall (UK: Penguin Classics 2003).

Unit 4

Fyodor Dostoyevsky *Crime and Punishment* (1866) trans. Oliver Ready (UK: Penguin Classics Deluxe Edition) 2014.

Unit 5
Readings

a) Honoré de Balzac 'Society as Historical Organism' from Preface to 'The Human Comedy' in *The Modern Tradition* ed. Richard Ellmann et al. (Oxford: OUP 1965) pp. 265-67.
b) V. G. Belinsky 'Letter to Gogol (1847)' in *Selected Philosophical Works* (Moscow: Moscow Foreign Languages Publishing House 1948) pp. 506-07.
c) Gustave Flaubert 'Heroic Honesty' in *The Modern Tradition* ed. Richard Ellmann et al. (Oxford: OUP 1965) pp. 242-43.
d) Leo Tolstoy 'Man as Creature of History' in *The Modern Tradition* ed. Richard Ellmann et al. (Oxford: OUP 1965) pp. 246-54.
e) György Lukàcs 'Balzac and Stendhal' in *Studies in European Realism* (London: Merlin Press 1972) pp. 65-85.

Teaching Plan
Paper D10: Nineteenth Century European Realism

Week 1: Introduction to Paper D10: Nineteenth Century European Realism
Week 2: French Revolution: Impact on the Novel as a form.
Week 3: Reading Balzac's theory of human comedy: 'Society as Historical Organism' And *Old Man Goriot* as examples.
Week 4: *Old Man Goriot* as a realist novel.
Week 5: Shift from Realism to Naturalism in 19th Century French Literature.
Week 6: Reading Flaubert's essay and Madame Bovary as texts of historical transition.
Week 7: Discussion on Madame Bovary continued.
Week 8:The Russian context in the 19th Century: From the Napoleonic Wars to the Emancipation.
Week 9: The Russian politics between the Slavophiles and the Westerners: Belinsky's letter to Gogol 1847
Week 10: Turgenev *Fathers and Sons*: Critique of peasantry and aristocracy.
Week 11: Turgenev (contd): A critique of emancipation.
Week 12: Leo Tolstoy: 'Man as a Creature of History'.
Week 13: Dostoevsky *Crime and Punishment*: a novel of conflicting ideologies.
Week 14: Dostoevsky (contd).

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords
French Revolutions
Agrarian feudalism
Positivism
Scientific determinism
Industrial capitalism
Novel and history
Emancipation of the serfs
Naturalism
The woman question
Novel
Ideology

Sub-committee

Rudrashish Chakraborty Kirori Mal College (Coordinator)
Saikat Ghosh SGTB Khalsa College
Dhananjay R. Kapse Kirori Mal College
Madhvi Zutshi SGTB Khalsa College
N. A. Jacob Ramjas College
Shraddha Adityavir Singh Zakir Husain Delhi College

Advisors
Dr. Rimli Bhattacharya Dept. of English
Prof. Shaswati Mazumdar Dept. of Germanic and Romance Studies

PAPER D11
AFRICAN LITERATURES
Semester 6

Course Statement

This course is for students who may wish to engage further with African literatures while studying the Core Postcolonial Literatures paper. It asks the questions:*What is African literature? How is it different from other literatures of the world? Why do African writers write predominantly in English and French? How is womanhood depicted in African fiction?* These questions are answered by engaging with a variety of texts from the continent some written originally in English while others available today in translations.

Course Objectives

This course aims to

- introduce students to a detailed analysis of African literatures in different genres and
- chart the distinctive position that African literatures have today in the postcolonial world.

Unit 1

Flora Nwapa *Efuru* (Heinemann 1966).

Unit 2

Sembène Ousmane *Xala* (Heinemann 1976).

Unit 3

Wole Soyinka ‘A Dance of the Forests’ in *Collected Plays: Vol 1* (OUP 1997).

Unit 4
Short stories
a) Nadine Gordimer ‘Jump’ in *The Individual and Society* (University of Delhi Department of English New Delhi: Pearson 2005).
b) Grace Ogot ‘The Green Leaves’ in *Land without Thunder* (Kenya: East African Publishing House 1968).
c) Leila Aboulela ‘Missing Out’ in *The Granta Book of the African Short Story*ed. Helon Habila (Granta 2012).
d) Chimamanda Adichie ‘A Private Experience’ in *The Thing around Your Neck* (UK: Fourth Estate 2009).

Poems

a) Gabriel Okara 'Once upon a time' in *Collected Poems* African Poetry Book Series ed. Brenda Marie Osbey (University of Nebraska Press 2016).
b) Otok P. Bitek 'Song of Lawino' in *Anthology of African Literature* ed. Anthonia C. Kalu (New Delhi: Viva Books 2012) pp. 739-51.

c) Beyten Breytenbach 'New York September 12 2001' at https://www.poemhunter.com/poem/new-york-september-12-2001/

Unit 5
Readings

a) Frantz Fanon 'The Negro and Language' trans. Charles Lam Markmann in Black Skin White Masks (London: Pluto Press 2008) pp. 8-20.
b) Nelson Mandela (i) 'The Struggle is My Life' Part 4 and (ii) 'Riviona' Part 7in *Long Walk to Freedom* (London: Abacus 1995) pp. 153-64 319-22.
c) Ezekiel Mphahlele (i) 'The African Personality' (ii) 'What Price Negritude?' (The white man's policy on apartheid…in other parts of Africa) in *The African Image* (New York: Frederick A Praeger 1962) pp. 19-24 31-39.
d) Chinua Achebe 'The African Writer and the English Language' in *Morning yet on Creation Day* (London: Heinemann 1975).
e) Chimananda Adichie *We Should All Be Feminists* (New York: Vintage 2014).

Teaching Plan
Paper D11: African Literatures

Week 1 – Introduction to Paper 11: African Literatures
Week 2 – Unit 1 – Novel: Nwapa *Efuru*
Week 3 – Nwapa (contd)
Week 4 – Unit 2 -- Novel: Ousmane *Xala*
Week 5 – Ousmane (contd0
Week 6 – Unit 3 – Drama: Soyinka 'A Dance of the Forests'
Week 7 – Soyinka (contd)
Week 8 – Unit 4 -- Short stories:
(a) Gordimer 'Jump'
(b) Ogot 'The Green Leaves'
(c) Aboulela 'Missing Out'
(d) Adichie
Week 9– Short Stories (contd)
Week 10 – Unit 4 -- Poetry:
(a) Okara 'Once upon a time'

(b) Bitek ‘Song of Lawino’
(c) Breytenbach ‘New York September 12 2001’

Week 11 – Unit 5 -- Prose Readings:

(a) Fanon ‘The Negro and Language’
(b) Mandela (i) ‘The Struggle is My Life’ Part 4 and (ii) ‘Riviona’ Part 7 (c) Mphahlele (i) ‘The African Personality’(ii) ‘What Price Negritude?’
(d) Achebe ‘The African Writer and the English Language’
(e) Adichie *We Should All Be Feminists*

Week 12– Prose Readings (contd)
Week 13 – Prose Readings (contd)
Week 14 – Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Colonialism
Postcolonialism
Decolonisation
Gender

Sub-committee

Madhumita Chakraborty Zakir Husain College (E) (Coordinator)
Gitarani Devi Shivaji College
Nandini Sen Bharati College
Varsha Singh Deshbandhu College

PAPER D12

LATIN AMERICAN LITERATURE

Semester 6

Course Statement

The oral and written literatures of the Latin America are rich and varied in terms of history language culture ethnicity and literary tradition. This paper introduces to undergraduate students the landmarks of Latin American writing by including a representative selection of various forms/genres that encompasses the diversity and heterogeneity of the continent.

Course Objectives

This course aims to

- critically engage with innovation in form voice representation and various modes of storytelling that are specific to Latin American literature but are relevant to students of literary studies as it has impacted global literatures
- examine how the experimentation in terms of form and perspective engages with questions of identity dissidence resistanceand recuperation and resonates with the colonial and postcolonial histories and literatures of developing worlds and
- critically examine issues of race class gender culture and identity in order to understand the evolving character of Latin American society and to trace its resonances with literatures of the global South particularly with reference to India.

Course Content

Unit 1

Novel

Gabriel Garcia Marquez *The General in His Labyrinth* (Penguin 1990).

Unit 2

Short Stories

a) Jorge Luis Borges ‘The Library of Babel’ in *Fictions* (Penguin 1999) pp. 65-75.
b) Isabel Allende ‘Of Clay We Are Created’ in *The Stories of Eva Luna* (Penguin 1991).
c) Roberto Bolano ‘William Burns’ in *The Return* (New Directions 2010) pp. 52-69.
d) Juan Rulfo ‘Luvina’ in *The Penguin Book of Latin American Short Stories* ed. Thomas Colchie (London and New York 1993) pp. 283-90.

Unit 3
Poetry

a) Pablo Neruda (i) 'Rise up and be born with me' (XII) from'The Heights of Machu Picchu in *The Essential Neruda: Selected Poems* ed. Mark Eisner (San Francisco: City Lights Books 2004) pp. 90-91 (ii) 'Every Day You Play' in Pablo *Neruda: Selected Poems* (Penguin 1975) pp. 27-28.
b) Octavio Paz (i) 'As One Listens to the Rain' and (ii) 'Between What I See and What I Say' in *The Collected Poems of Octavio Paz* 1957-1987 ed. Eliot Weinberger (New York: New Directions 1991) pp. 614-16 485-87.
c) Gabriela Mistral(i) 'The Story Teller' and (ii) 'Ballerina' in *Madwomen: The Locas Mujeres Poems of Gabriela Mistral* Bilingual edition ed. and trans. Randall Couch (Chicago and London: The University of Chicago Press 2008) pp.103-107 43-45.
d) Jose Marti (i) 'A Sincere Am I' and (ii) 'Once I was Sailing for Fun' trans. Manuel A. Tellechea in *Versos Sencillos/ Simple Verses* (Houston Texas: Arte Publico Press 1997) pp. 52-53 16-21.

Unit 4
Testimonio/Memoir

a) Rigoberta Menchu *I Rigoberta Menchu an Indian Woman from Guatemala* trans. Ann Wright ed. Elizabeth Burgos Debray (London and New York: Verso 1984) pp. 1-37.
b) Che Guevara *The Motorcycle Diaries: Notes on a Latin American Journey* (Melbourne and New York: Ocean Press 2004) pp. 44-77.
c) Alicia Partnoy *The Little School: Tales of Disappearance and Survival* (San Franciso: Midnight Editions Cleis Press 1986) pp. 77-95.

Unit 5

Readings

a) Bartolomé De Las Casas *The Devastation of the Indies: A Brief Account* trans. Herma Briffaul (Baltimore and London: Johns Hopkins University Press 1974) pp. 27-57.
b) Alejo Carpentier 'On the Marvelous Real in America' in Magical *Realism: Theory History and Communi*ty eds Lois P. Zamora and Wendy B. Faris (Durham and London: Duke University Press 1995) pp. 75-89.
c) Eduardo Galeano *Open Veins of Latin America: Five Centuries of Pillage of a Continent* (Delhi: Three Essays Collective 2008) pp. 1-28.
d) Roberto Fernando Retamar *Caliban and Other Essays*(Minneapolis: University of Minnesota Press 1989) pp.3-16.
e) Gabriel Garcia Márquez 'The Solitude of Latin America' Nobel Lecture in *Gabriel Garcia Marquez: New Readings* eds. Bernard Mc Guirk and Richard Cardwell Cambridge University Press 1987) pp. 207-12

Teaching Plan
Paper D12: Latin American Literature

Week 1 -- Introduction to the Paper D12: Latin American Literature
Week 2 -- Unit 1 – Novel: Marquez The General in His Labyrinth
Week 3 -- Unit 1 (contd)
Week 4 -- Unit 1 (contd)
Week 5 -- Unit 2 – Short Stories:
(a) Borges 'The Library of Babel'
(b) Allende 'Of Clay We Are Created'
Week 6 -- Unit 2 (contd): Bolano 'William Burns' Rulfo 'Luvina'
Week 7 -- Unit 2 (contd)
Week 8 -- Unit 3 – Poetry:
(a) Neruda 'Rise up and be born with me' 'Every Day You Play'
(b) Paz 'As One Listens to the Rain' 'Between What I See and What I Say'
Week 9 -- Unit 3 – (contd):
(c) Mistral 'The Story Teller' 'Ballerina' (d) Marti 'A Sincere Am I' 'Once I was Sailing for Fun'
Week 10 -- Unit 4 – Testimonio/Memoir:
(a) Menchu I Rigoberta Menchu an Indian Woman from Guatemala
(b) Guevara The Motorcycle Diaries: Notes on a Latin American Journey
Week 11 -- Unit 4 – (contd):
(c) Partnoy The Little School: Tales of Disappearance and Survival

Week 12 -- Unit 5 -- Background Prose Readings:
(a) Las Casas 'The Devastation of the Indies: A Brief Account'
(b) Carpentier 'On the Marvelous Real in America'
Week 13 -- Unit 5 (contd):
(c) Galeano Open Veins of Latin America: Five Centuries of Pillage of a Continent Retamar Caliban and Other Essays
(d) Márquez Nobel Lecture: 'The Solitude of Latin America'
Week 14 -- Concluding lecture exam questions

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions

2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Magical realism
Latin America
LatAm literature
Memory
Resistance
Marquez
Octavio Paz
Testimonio
Testimonial
Neruda

Sub-committee

Mukul Chaturvedi Zakir Husain College (Coordinator)
Krishnan Unni P Deshbandhu College
Shivranjani Singh Dyal Singh College
Shraddha Adtiyavir Singh Zakir Husain College
Smita Bannerjee DCAC
With inputs from:
Dhananjay Kapse Kirori Mal College
Rudrashish Kirori Mal College
Shweta Sachdev Miranda House

PAPER D13
LITERARY CRITICISM AND THEORY - 2
Semester 6

Course Statement

This course explores some of the crucial theoretical concerns in literary studies in the twentieth century. Beginning with Freudian psychoanalysis after the First World War the paper introduces some of the seminal concepts of critical theory including historical materialism structuralism poststructuralism feminism postcolonialism and cultural studies. It underlines a tectonic shift in literary studies in the twentieth century: from literature as 'a formal artifice' to a 'cultural intertext'—an interdisciplinary approach which establishes literature as a socially symbolic act.

Course Objectives

The course aims to

- expose students to the history of ideas in the twentieth century and the material and discursive conditions of intellectual production
- encouragestudents to grapple with literary studies from a privileging of form to an interdisciplinary engagement with the literary text
- help students develop a critical wherewithal which would enable her to engage with a literary text from multiple pedagogical entry-points and
- have students closely examine the methods of argument and rhetorical constructions through which important theoretical ideas and concepts have been established and made to impact the field of cultural production in the West.

Course Content

Unit 1

a) Antonio Gramsci 'The Formation of the Intellectuals' and 'Hegemony (Civil Society) and Separation of Powers' in *Selections from the Prison Notebooks* (1939) ed. and trans. Quentin Hoare and Geoffrey Nowell Smith (New Delhi: Orient Longman 1998) pp. 5-14 245-246.
b) György Lukàcs'The Phenomenon of Reification' trans. Rodney Livingstone in *History and Class Consciousness: Studies in Marxist Dialectics* (1939) (London: Merlin Press 2003) pp. 83-109.
c) Louis Althusser 'Ideology and Ideological State Apparatuses' trans. Ben Brewster in *Lenin and Philosophy and Other Essays* (1970) (New Delhi: Aakar Books 2006) pp. 85-126.

Unit 2

a) Claude Levi-Strauss 'The Science of the Concrete' trans. George Weidenfeld in *The Savage Mind* (1962) (Chicago: University of Chicago Press 1967) pp. 1-35.
b) Jacques Derrida 'Structure Sign and Play in the Discourse of Human Sciences' trans. Alan Bass in *Writing and Difference* (1967) (New York London: Routledge 1978) pp. 351-70.
c) Michel Foucault 'The Order of Discourse' trans. Ian McLeod in *Untying the Text: A Post-structuralist Reader* ed. Robert J. Young (Boston MA: Routledge 1981) pp. 48-78.

Unit 3

a) Sigmund Freud 'The Uncanny' trans. David McLintock in *The Uncanny* (1919) (London: Penguin Books 2003) pp. 1-21.

b) Jacques Lacan 'The Mirror Stage' trans. Alan Sheridan in *Ecrits: A Selection* (1949) (New York London: Routledge 1989) pp. 1-8.

c) Julia Kristeva (i) 'The Semiotic Chora Ordering the Drives' and (ii) 'The Thetic: Rupture and/or Boundary' trans. Margaret Waller in *Revolution in Poetic Language* (1974) (New York: Columbia University Press 1984) pp. 25-30 43-45.

Unit 4

a) Luce Irigaray (i) 'This Sex Which Is Not One' and (ii) 'Commodities Amongst Themselves' trans. Catherine Porter and Carolyn Burke in *This Sex Which is Not One* (1977) (Ithaca New York: Cornell University Press 1985) pp. 23-33 192-97.

b) Judith Butler (i) 'Preface 1990' (ii) 'Women as the Subject of Feminism' (iii) 'Bodily Inscriptions Performative Subversions'in *Gender Trouble: Feminism and the Subversion of Identity* (New York: Routledge 1999) pp. xxvii- xxix 3-18 163-80.

c) Joan W. Scott 'Gender: A Useful Category of Historical Analysis' *The American Historical Review* Vol. 91 No. 5 (Dec. 1986) pp. 1053-75.

Unit 5

Readings

a) Theodor Adorno 'The Schema of Mass Culture' trans. J. M. Bernstein in *The Culture Industry: Selected Essays on Mass Culture* (1972) (London: Routledge 2007) pp. 61-97.

b) Homi Bhabha 'How Newness Enters the World' in *The Location of Culture* (New York London: Routledge 1994) pp. 303-37.

c) Frederic Jameson 'Postmodernism Or The Cultural Logic of Late Capitalism' *New Left Review* No. 146 (July-August) 1984: 59-92.

Teaching Plan

Paper D13: Literary Criticism and Theory - 2

Week 1 – Introduction to Paper D13: Literary Criticism and Theory - 2

Week 2 – Unit 1

(a) Gramsci 'The Formation of the Intellectuals' and 'Hegemony (Civil Society) and Separation of Powers'

(b) Lukàcs 'The Phenomenon of Reification'

(c) Althusser 'Ideology and Ideological State Apparatuses'

Week 3 – Unit 1 (contd)

Week 4 – Unit 2

(a) Levi-Strauss 'The Science of the Concrete'

(b) Derrida 'Structure Sign and Play in the Discourse of Human Sciences'

(c) Foucault 'The Order of Discourse'

Week 5 – Unit 2 (contd)

Week 6 – Unit 3

(a) Freud 'The Uncanny'

(b) Lacan 'The Mirror Stage'

(c) Kristeva (i) 'The Semiotic Chora Ordering the Drives' (ii) 'The Thetic: Rupture and/or Boundary'

Week 7 – Unit 3 (contd)

Week 8 – Unit 4

(a) Irigaray (i) 'This Sex Which Is Not One' and (ii) 'Commodities Amongst Themselves'

(b) Butler (i) 'Preface 1990' (ii) 'Women as the Subject of Feminism' (iii) 'Bodily Inscriptions Performative Subversions'

(c) Scott 'Gender: A Useful Category of Historical Analysis'

Week 9– Unit 4 (contd)

Week 10 – Unit 4 (contd)

Week 11 – Unit 5: Readings

(a) Adorno 'The Schema of Mass Culture'

(b) Bhabha 'How Newness Enters the World'

(c) Jameson 'Postmodernism Or The Cultural Logic of Late Capitalism'

Week 12 – Readings (contd)

Week 13 – Readings (contd)

Week 14 – Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Hegemony
Ideology
Uncanny
Gender
Mass Culture
Postmodernism

Sub-committee

N. A. Jacob Ramjas College (Coordinator)
Saikat Ghosh (Coordinator) SGTB Khalsa College
Madhvi Zutshi SGTB Khalsa College
Rudrashish Chakraborty Kiori Mal College
Shraddha Adityavir Singh Zakir Husain Delhi College

Advisors

Dr. Rimli Bhattacharya Dept. of English
Prof. Shaswati Mazumdar Dept. of Germanic and Romance Studies

PAPER D14
LITERATURE AND CINEMA
Semester 6

Course Statement

Literature and cinema have had a close relationship with one another manifest in the celluloid 'adaptation' of classics and 'inspired' productions in the earlier days to the film text studies of recent times. The writer and the auteur both produce art that oftentimes is in conversation particularly since the cultural revolution of modernism. This paper attempts to trace the genealogy of this collaborative mediation between literature and cinema between the textual and the visual.

Course Objectives

This course aims to

- examine the close relationship between literature and cinema by studying the points of contact of literary and cinematic praxis
- enable students to study cinema as a composite medium since the texts under discussion will open space for examining cinema as audio-visual articulation

as adaptation/translation and as a form of (popular) culture with its own parameters of reception and its own history (movements/frameworks of study)

- equip students in a practical sense for understanding the cinematic medium
- examine cinema as an art employing different time frames situations literary cultures and other media/forms to compose itself as a text
- provide students with texts in emerging media thus broadening the field of literary study in relation to cinematic language
- stress the interdisciplinary nature of academic work by imparting skills of reading and understanding literary texts and cinematic expressions through the development of relevant critical vocabulary and perspective among students and
- provide a theoretical framework to strengthen the awareness about intertextuality and the convergence between the modes of literature and cinema.

Course Content

Unit 1

Language of Cinema: mise en scene film vocabulary signs and syntax
James Monaco'The Language of Film: Signs and Syntax' Chapter 3 in *How to Read a Film: The World of Movies Media and Multimedia* (New York: OUP 2009) pp. 170-249.

Unit 2

Origin of Cinema as a New Form of Art: questioning the traditional functions of art analyzing new art forms in the 20th century film as a new form of art silent cinema
Walter Benjamin'The Work of Art in the Age of Mechanical Reproduction.'

Film

Modern Times dir. Charlie Chaplin perf. Charlie Chaplin (1936).

Unit 3

Cinematic Adaptations of Literary Texts: theory of adaptation the relationship between literature and films film as an adapted text film itself

Drama

William Shakespeare *Macbeth* (1623).

Films

a) *Maqbool* dir. Vishal Bhardwaj (2003).
b) *Throne of Blood* dir. Akira Kurosawa (1957).

Unit 4

Gender and Sexuality connection with literature the difference between sexuality in films and that in literary texts the gaze the body representation cinematography
Laura Mulvey 'Visual Pleasure and Narrative Cinema' in *Film Theory and Criticism: Introductory Readings* eds Leo Braudy and Marshall Cohen (New York: Oxford UP 1999) pp. 833-44.

Films

a) *Thelma and Louise* dir. Ridley Scott (1991).
b) *Margarita with a Straw* dir. Shonali Bose (2014)

Unit 5
Readings

a) Madhava Prasad 'The Absolutist Gaze: The Political Structure and the Cultural Form' in *Ideology of the Hindi Film: A Historical Construction* pp. 48-82.
b) Ranjani Mazumdar'Gangland Bombay' in *Bombay Cinema: An Archive of the City* (Ranikhet: Permanent Black 2007) pp. 149-96.

Suggested films for this paper:
a) *Kaliyattam* dir. Jayaraaj (1997) Malayalam.
b) *Charulata* dir. Satyajit Ray (1965) Bangla.
c) *Enthiran* dir. S. Shankar (2010) Tamil.

Suggested readings for this paper:
a) Shail Andrew'From the Cinematograph to The Pictures' in *The Cinema and the Origins of Literary Modernism* New York and London: Routledge 2012) pp. 1-40.
b) Fernando Solanas and Octavio Getino 'Towards a Third Cinema' in *Movies and Methods: An Anthology* ed. Bill Nichols (Berkeley: University of California Press 1976) pp. 44–64.
c) Laura Mulvey'Afterthoughts on 'Visual Pleasure and Narrative Cinema' inspired by King Vidor's *Duel in the Sun* (1946)' in *Visual and Other Pleasures* (London: Palgrave Macmillan 1989).
d) bell hooks'The Oppositional Gaze: Black Female Spectators' in *Black Looks: Race and Representation* (Boston: South End Press 1992).

e) Robert Stam'Beyond Fidelity: The Dialogues of Adaptation' in *Film Adaptation* ed. James Naremore (New Brunswick NJ: Rutgers UP 2000) pp. 54-76.
f) Andre Bazin 'Adaptation or the Cinema as Digest' in *Film and Literature: An Introduction and Reader* ed. Timothy Corrigan pp. 57-64.
g) Anna Morcom'Tapping the Mass Market: The Commercial Life of Hindi Film Songs' in *Global Bollywood: Travels of Hindi Song and Dance* eds Sangita Gopal and Sujata Moorti (Delhi: Orient Blackswan 2010) pp. 63-84.

Teaching Plan

Paper D14: Literature And Cinema

Week 1 – Unit 1 - Language of Cinema: mise en scene - film vocabulary - signs and syntax Readings: Monaco 'The Language of film: signs and syntax'
Week 2 – Unit 1 (contd)
Week 3 – Unit 1 (contd)
Week 4 – Unit 2 -- Origin of Cinema as a New Form of Art: Questioning the traditional functions of art - new art forms in the 20th century - Film as a new form of art - silent cinema
Readings: Benjamin 'The Work of Art in the Age of Mechanical Reproduction'
Film: *Modern Times*
Week 5 – Unit 2 (contd)
Week 6 – Unit 2 (contd)
Week 7 – Unit 3 – Cinematic Adaptations of Literary Texts: Theory of adaptation – relationship between literature and films - film as an adapted text - film itself
Readings: *Macbeth* Films: (a) *Maqbool* (b) *Throne of Blood*
Week 8 – Unit 3 (contd)
Week 9 – Unit 3 (contd)
Week 10 -- Unit 4 – Gender and Sexuality: Connection with literature - how sexuality in films different from literary texts - gaze - body –representation – cinematography
Readings: Mulvey 'Visual Pleasure and Narrative Cinema' Films: (a) *Thelma and Louise* (b) *Margarita with a Straw*
Week 11 – Unit 4 (contd)
Week 12 – Unit 4 (contd)
Week 13 – Unit 5 – Background Prose Readings: (a) Prasad 'The Absolutist Gaze: The Political Structure and the Cultural Form' (b) Mazumdar 'Gangland Bombay'
Week 14 – Unit 5 (contd)

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Cinema
Literature
Adaptation
Gender
Sexuality

Sub-committee

Mithuraaj Dhusiya Hansraj College (Coordinator)
Dhananjay Kapse Kirorimal College
Gorvika Rao Miranda House
Jenny Rowena Miranda House
Krishnan Unni.P Deshbandhu College
Namita Paul Kamla Nehru College

Paper D15

LITERATURE AND DISABILITY

Semester 6

Course Statement

Over the past two decades literary and cultural disability studies have opened up new discursive spaces from where the traditional notion of disability as a state of negative difference in relation to normalcy can be interrogated and problematized. Though this discipline has been insititutionalised in the West for quite some time now it is yet to find its way into the English departments of Indian universities. This paper introduces undergraduate students to this new discipline and acquaints them with the experience of disablement through a familiarization with literary representations of the phenomenon.

Course Objectives

This course aims to

- help students approach literature through the lens of disability and enable them to develop a fresh critical perspective for reading literary representations
- enable them to explore various forms of literary representations of disability in order to become aware of the different ways in which disability figures and operates in a literary narrative
- develop through a reading of literature a critical understanding of the relation between the impaired body and the social world and the matrix of power that structures and defines this relationship
- equip students with the necessary critical tools to analyze representations of disability and to develop the ability to systematically understand and unpack the various discursive processes through which the hegemony of normalcy is constituted and perpetuated
- help students understand how literature is used to negotiate and interrogate this hegemony and to evolve an alternative conception of corporeal difference
- inculcate in them an approach to disability based on notions of intersectionality that is to understand the experience of disablement in conjunction with other forms of marginalised identities
- evolve an understanding of disability in relation to the contemporary contexts of capitalism and neo-liberalism emphasising inclusive political agendas built on notions of cultural diversity and the changing meaning of citizenship and citizen's rights and
- introduce the undergraduate student to the fundamental tenets of literary and cultural disability studies with the professed intention of bringing about a change in the way that we have been traditionally responding to disability and disabled people.

Course Content

Unit 1
Novel

Firdaus Kanga *Trying to Grow* (1991) (New Delhi India: Penguin 2008).

Unit 2
Autobiography

a) Helen Keller (i) *The Story of My Life* (1903) Chapters 3 4 5 6 8-15 (New York: Simon and Schuster Paperbacks 2010) (ii) 'How I Became a Socialist' in *Helen Keller: Her Socialist Years* ed. Philip S. Foner (New York: International Publishers 1967) pp. 21–26.
b) Georgina Kleege *Sight Unseen* Chapter 1 (New Haven and London: Yale University Press 1999).
c) Naseema Hurzuk *Naseema: The Incredible Story* trans. Asha Deodhar ed. Rukmini Sekhar (New Delhi: The Visaka Foundation 2006).
d) Malini Chib 'Why Do You Want To Do BA' *One Little Finger* (New Delhi: Sage 2011) 49–82.
e) Tito Rajarshi Mukhopadhyay (i) 'No Wonder I Don't Talk' (18) (ii) 'Flapping My Hands Flapping My Shadow' (21) (iii) 'Autism! A Fancy Word' (22-23) (iv) 'Why was Mother Stopping Me from Climbing?' (30) (v) 'Feeding My Body' (44-45) (vi) 'Wish He Could Dress Himself!' (46-47) (vii) 'How Do You Perceive a Linear Situation' (55-56) (viii) 'Exposure Helps Shape Visual Perception' (67-8) and (ix) 'Learning to Write' (90) all in *How Can I Talk If My Lips Don't Move: Inside My Autistic Mind* (New York: Arcade Publishing 2008).

Unit 3
Short Stories

a) Daniel Keyes 'Flowers for Algernon' *The Magazine of Fantasy and Science Fiction* Vol. 16: 4 (April 1959) pp. 5-30.
b) Andre Dubus 'Dancing After Hours' in *Dancing After Hours: Stories* (New York: Knopf Doubleday Publishing 2011) pp. 240-56.
c) Anne Finger 'Comrade Luxemburg and Comrade Gramsci Pass Each Other at a Congress of the Second International in Switzerland on the 10th of March 1912' in *Call Me Ahab: A Short Story Collection* (United States of America: Library of Congress 2009) pp. 61–72.

d) Rabindranath Tagore 'Dhristidaan' trans. Arunava Sinha in *Seminar* on 'The Nation and Its Poet: A Symposium on Rabindranath Tagore 1861-1941: Life Language Legacy' Vol. 623 (July 2011) pp. 71-79.

e) Rashid Jahan 'Woh' (That One) trans. M.T. Kahn in *Women Writing in India 600 BC to the Present Vol. 2* eds Susie Tharu and K. Lalita (New York: The Feminist Press 1993) pp. 119-22.

Unit 4

Drama

Girish Karnad 'Broken Images' in *Collected Plays. Vol. II*. (New Delhi: Oxford University Press 2005) pp. 261–87.

Poetry

a) Vassar Miller 'Dramatic Monologue in the Speaker's Own Voice' in *Beauty is a Verb: The New Poetry of Disability* ed. Jennifer Bartlett Sheila Black and Michael Northen (USA and Mexico: Cinco Press 2011) p. 51.

b) Jim Ferris 'Poems With Disabilities' in *Beauty is a Verb: The New Poetry of Disability* ed. Jennifer Bartlett Sheila Black and Michael Northen (USA and Mexico: Cinco Press 2011) p. 89.

c) Raghuvir Sahay 'The Handicapped Caught in a Camera' trans. Harish Trivedi *Chicago Review* Vol. 38: 1/2 (1992) pp. 146-7.

d) Jyotsna Phanija 'See' in *Ceramic Evening* (New Delhi: Writers Workshop 2016) p. 49.

Unit 5

Readings

a) Simi Linton 'Disability Studies/Not Disability Studies' *Disability & Society* Vol. 13.4 (1998) pp. 525-40.

b) Lennard J. Davis 'Constructing Normalcy' in *Enforcing Normalcy: Disability Deafness and the Body* (London and New York: Verso 1995) pp. 23–49.

c) Ato Quayson 'A Typology of Disability Representation' in *Aesthetic Nervousness: Disability* *and the Crisis of Representation* (Columbia: Columbia University Press 2007) pp. 32–53.

d) Thomas Couser 'Signifying Selves: Disability and Life Writing' in *The Cambridge Companion on Literature and Disability* eds Clare Barker and Stuart Murray (New York: Cambridge University Press 2017) pp. 199–211.

e) Shilpaa Anand 'Historicizing Disability in India: Questions of Subject and Method' in *Disability Studies in India: Global Discourses Local Realities* ed. Renu Addlakha (New York: Routledge) pp. 35–60.

f) Das Veena and Renu Addlakha "Disability and Domestic Citizenship: Voice Gender and the Making of the Subject" Public Culture Vol. 13:3 (2001) pp. 511-531.

Teaching Plan

Paper D15: Literature and Disability

Week 1 – Introduction to Paper D15: Literature and Disability
Week 2 – Unit 1 – Novel: Kanga *Trying to Grow*
Week 3 – Kanga (contd)
Week 4 – Unit 2 – Autobiography:

(a) Keller (i) *The Story of My Life* Chapters 3 4 5 6 8-15 (ii) 'How I Became a Socialist' pp. 21–26.
(b) Kleege *Sight Unseen* Chapter 1
(c) Hurzuk *Naseema: The Incredible Story*
(d) Chib 'Why Do You Want To Do BA' *One Little Finger* 49–82.
(e) Mukhopadhyay (i) 'No Wonder I Don't Talk' (18) (ii) 'Flapping My Hands Flapping My Shadow' (21) (iii) 'Autism! A Fancy Word' (22-23) (iv) 'Why was Mother Stopping Me from Climbing?' (30) (v) 'Feeding My Body' (44-45) (vi) 'Wish He Could Dress Himself!' (46-47) (vii) 'How Do You Perceive a Linear Situation' (55-56) (viii) 'Exposure Helps Shape Visual Perception' (67-8) and (ix) 'Learning to Write' (90)

Week 5 – Autobiography (contd)
Week 6 – Autobiography (contd)
Week 7 – Unit 3: Short Stories:

(a) Keyes 'Flowers for Algernon'
(b) Dubus 'Dancing After Hours'

(c) Finger 'Comrade Luxemburg and Comrade Gramsci Pass Each Other at a Congress
of the Second International in Switzerland on the 10th of March 1912'
(d) Tagore 'Dhristidaan'
(e) Rashid Jahan 'Woh' (That One)

Week 8 – Short Stories (contd)
Week 9 – Unit 4: Drama: Karnad *Broken Images*
Week 10 – Unit 4: Poetry:
(a) Miller 'Dramatic Monologue in the Speaker's Own Voice'
(b) Ferris 'Poems With Disabilities'
(c) Sahay 'The Handicapped Caught in a Camera'
(d) Phanija 'See'

Week 11 – Unit 5 -- Prose Readings:
(a) Linton 'Disability Studies/Not Disability Studies'
(b) Davis 'Constructing Normalcy'
(c) Quayson 'A Typology of Disability Representation'
(d) Couser 'Signifying Selves: Disability and Life Writing'
(e) Anand 'Historicizing Disability in India: Questions of Subject and Method'
(f) Anita Ghai 'Disabled Women: Issues Concerns and Voices from Within'

Week 12 – Prose Readings (contd)
Week 13 – Prose Readings (contd)
Week 14 – Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Disability representation
Narrativising disability
Normalcy
Ableism
Marginality
Identity and Agency

Sub-committee

Someshwar Sati Kirori Mal College (Coordinator)
Alamelu Indraprastha College for Women
B. Mangalam Aryabhatta College
Karuna Rajeev Lady Shri Ram College for Women
Rohith Deen Dyal Upadhyay College
Viraj Kafle Dyal Singh College (Morning)

PAPER D16
PARTITION LITERATURE
Semester 6

Course Statement

This paper looks at representations of the Partition of India in 1947. It aims to give the students a comprehensive range of literary responses to one of the subcontinent's most traumatic histories of vivisection trauma and violence. The paper encompasses literatures from Punjab PakistanWest Bengal the Northeast and Bangladesh though the varied genres: memoirs short stories and the novel along with theoretical background reading materials.

Course Objectives

This paper aims to

- enable an understanding of the affective dimensions of the Partition in varied geopolitical spaces
- aid the student in comprehending the country's postcolonial realities and
- introduce students to the following topics through the study of literary texts: colonialism nationalisms and the Partition of India in 1947 communalism violence and the British Rule in India homelessness exile and migration women and children in the Partition refugees rehabilitation and resettlement borders and borderlands.

Course Content

Unit 1
Novel
Intizaar Hussain *Basti* Tr. Frances W Pritchett 1995.

Unit 2
Novel

Sunil Gangopadhyay,*Arjun* (originally Bangla *Arjun*) trans. Chitrita Bannerjee (Penguin 1987).

Unit 3
Short Stories

a) Manto'Toba Tek Singh'(Urdu Pakistan) trans. Harish Trivedi in *Modern Indian Literature* (Department of English Delhi University) pp. 105-114.
b) Krishan Chander'Peshawar Express' (Urdu Punjab) trans. Jai Ratan in *Stories About the Partition of India* ed. Alok Bhalla (Delhi: Indus 1994) Vol. 3 pp. 205-215.
c) Manik Bandopadhyay 'Final Solution' (Bangla West Bengal) trans. Rani Ray in *Mapmaking: Partition Stories from Two Bengals* ed. Debjani Sengupta (Delhi: Amaryllis 2011) pp. 17-30.
d) Sunanda Bhattacharya 'Border Stories' (Bangla Tripura 'Borderer Golpo') trans. Debjani Sengupta in *Looking Back: The 1947 Partition of India 70 Years On* eds. Rakhshanda Jalil Tarun Saint and Debjani Sengupta (Delhi: Orient BlackSwan 2017) pp. 265-76.
e) Syed Waliullah'The Story of a Tulsi Plant' (Bangla Bangladesh) trans. Rani Ray in *Mapmaking* pp.101-114.

Unit 4
Memoirs/Reminiscences

a) Fikr Taunsvi 'The Sixth River' (Urdu 'Chhata Dariya') trans. Maaz Bin Bilal in *Looking Back: The 1947 Partition of India 70 Years On* eds. Rakhshanda Jalil Tarun Saint and Debjani Sengupta (Delhi: Orient BlackSwan 2017) pp. 148-61.
b) Himani Bannerji 'Wandering Through Different Spaces' in *The Trauma and The Triumph: Gender and Partition in Eastern India* Vol. 2 eds Jasodhara Bagchi and Subhoranjan Dasgupta (Kolkata: Stree 2009) pp. 105-30.
c) Hena Das 'Kaloibibi: A Leader of the Nankars' in *The Trauma and the Triumph* Vol. 2 pp. 143-56.

Unit 5
Readings

a) Ritu Menon and Kamla Bhasin 'Introduction' in *Borders and Boundaries* (Delhi: Kali For
Women 1998).
b) Urvashi Butalia Chapter 4 in *The Other Side of Silences: Voices from the Partition of India*
(Kali for Women 2000) pp. 109-171.
c) Ashis Nandy 'The Invisible Holocaust and the Journey as an Exodus' in *A Very Popular
Exile* (Delhi OUP 2007) pp. 98-139.

Teaching Plan
Paper D16: Partition Literature

Week 1: Introduction to Paper D16: Partition Literature
Week 2 – Unit 1 -- Novel: Hussain *Basti*
Week 3 – Unit 1 – Hussain (contd)
Week 4 – Unit 2 -- Novel: Gangopadhyay *Arjun*
Week 5 – Unit 2 – Gangopadhyay (contd...)
Week 6 – Unit 3 -- Short Stories:
(a) Manto 'Toba Tek Singh'
Week 7 – Unit 3 –Short Stories (contd):
(b) Chander 'Peshawar Express'
(c) Bandopadhyay 'Final Solution'
Week 8 – Unit 3 –Short Stories (contd):
(d) Bhattacharya 'Border Stories' '
(e) Waliullah 'The Story of a Tulsi Plant'
Week 9 – Unit 4 -- Memoirs/Reminiscences:
(a) Taunsvi 'The Sixth River'
(b) Bannerji 'Wandering Through Different Spaces'
Week 10 – Unit 4 -- Memoirs/Reminiscences (contd):
(c) Das 'Kaloibibi: A Leader of the Nankars'
Week 11 – Unit 5 -- Readings:
(a) Menon and Bhasin 'Introduction'
Week 12 – Unit 5-- Readings (contd):
(b) Butalia Chapter 4 in *The Other Side of Silences: Voices from the Partition of India*
Week 13 – Unit 5 –Readings (contd):
(c) Nandy 'The Invisible Holocaust and the Journey as an Exodus'
Week 14 - Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Nationalism
Partition
Communalism
Borders and Borderlands
Gender and Violence
Refugees and Rehabilitation
Migration and Exile
Children and Marginalized Experiences of the Partition

Sub-committee

Debjani Sengupta IP College (Coordinator)
Dhananjay Kapse Kirori Mal College
Parul Bhardwaj Miranda House
Yamini Dyal Singh College

PAPER D17

PRE-COLONIAL INDIAN LITERATURES

Semester 6

Course Statement

While Classical Indian literature and Modern Indian literature have become well established in many university curricula the prolific oral and scribal output of the so-called ‘medieval’ period remains under-studied in the Indian classroom. A paper on pre-colonial Indian literatures is indispensible to the analysis—and interrogation—of categories such as classical traditional pre-modern and modern.

Course Objectives

This course aims to

- introduce students to the culturally and evocatively rich literatures of pre-colonial early modern India
- explore concepts of devotional and secular love through Bhakti and Sufi poetry indigenous forms of narratives and story-telling through Kathas and Dastans and the gendered re-working of myths and histories through women’s narratives
- introduce a bridge between classical and modern Indian literatures and
- engage with the continuities as well as breaks among different narrative and verse traditions of Indian literature.

Course Content

Unit 1

Devotion

a) Nammalvar ‘My Lord My Cannibal’ trans. A.K. Ramanujan in *Hymns For the Drowning*.

b) Mahadeviakka (i) ‘Why do I need this dummy’ (ii) ‘I have Maya for mother-in-law’ trans.
A.K. Ramanujan in *Speaking of Siva*.

c) Tukaram (i) ‘Born a Shudra I have been a trader’ (ii) ‘I am telling you’ (iii) ‘I have seen my
death’ trans. Dilip Chitre in *Says Tuka*.

d) Ravidas (i) ‘Oh well born of Benares’ (ii) ‘The regal realm with the sorrowless name’ trans.
Hawley and Jurgensmeyer in *Songs of the Saints of India.*

e) Amir Khusrau (i) ‘Don’t Be Heedless of My Sorry State’ (ii) ‘You are the friend to sorrowful
hearts’ trans. Losensky and Sharma in *In the Bazaar of Love*.

Unit 2
Love

a) Jayadeva *Gitagovinda* Parts 1-5 (Krishna: joyful careless bewildered tender longing for
love) trans. Barbara Stoler Miller pp. 69-94.
b) Manjhan *Madhumalati* Verses 77-99 (Nymphs and Madhumalati described) Verses 401-417
(The Seasons of Madhumalati's Separation) trans. Aditya Behl (New Delhi: OUP) pp. 33-43
168-75.

Unit 3
Story

a) Somadeva *Kathasaritsagara*Book 1 - Kathapitha trans. Arshia Sattar pp. 1-49.
b) Ghalib Lakhnavi and Abdullah Bilgrami *Dastan-e-Amir-Hamza* Chapters 52 55 (Aasman
Peri) trans. Musharraf Ali Farooqi.

Unit 4
Women's voices

a) 'Chandravati Ramayana' trans. Mandkranta Bose and Sarika Priyadarhini Bose in *A*
Woman's Ramayana: Candravati's Bengali Epic pp. 52-91.
b) Gul-badan Begum from 'Humayun Nama' in *Women Writing in India* Vol. 1 pp. 99-102.

Unit 5
Prose readings

a) Aditya Behl 'Introduction to the *Madhumalati* pp. xi-xlvi.
b) Sheldon Pollock ed. *Literary Cultures in History* (New Delhi: OUP 2003) pp. 1-36.
c) Francesca Orsini 'How to do multilingual literary history? Lessons from fifteenth- and
sixteenth-century north India' *The Indian Economic and Social History Review* 49 2 (2012)
pp. 225–46.
d) G. N. Devy 'A Never Ending Transition' in *After Amnesia* (New Delhi: Orient
Longman 1992) pp. 56-101.

Teaching Plan

Paper D17: Pre-colonial Indian Literatures

Week 1 – Introduction to Paper D17: Pre-Colonial Indian Literatures
Week 2 – Unit 1 – Devotion:

(a) Nammalvar 'My Lord My Cannibal'

(b) Mahadeviakka (i) 'Why do I need this dummy' (ii) 'I have Maya for mother-in-law'

(c) Tukaram (i) 'Born a Shudra I have been a trader' (ii) 'I am telling you' (iii) 'I have seen my death'

(d) Ravidas (i) 'Oh well born of Benares' (ii) 'The regal realm with the sorrowless name'

(e) Khusrau (i) 'Don't Be Heedless of My Sorry State' (ii) 'You are the friend to sorrowful hearts'

Week 3 – Devotion (contd)
Week 4 – Devotion (contd)
Week 5 – Unit 2: Love

(a) Jayadeva *Gitagovinda* Parts 1-5 (Krishna: joyful careless bewildered tender longing for love) trans. Barbara Stoler Miller pp. 69-94.

(b) Manjhan *Madhumalati* Verses 77-99 (Nymphs and Madhumalati described)

Verses 401-417 (The Seasons of Madhumalati's Separation)

Week 6 – Love (contd)
Week 7 – Unit 3: Short Stories:

(a) Somadeva *Kathasaritsagara* Book 1 – Kathapitha

(b) Ghalib Lakhnavi and Abdullah Bilgrami *Dastan-e-Amir-Hamza* Chapters 52 55 (Aasman Peri)

Week 8 – Short Stories (contd)

Week 9 – Unit 4: Women's Voices:

(a) 'Chandravati Ramayana' trans. Mandkranta Bose and Sarika Priyadarhini Bose

(b) Gul-badan Begum from 'Humayun Nama'

Week 10 – Women's Voices (contd)
Week 11 – Unit 5 -- Prose Readings:

(a) Behl 'Introduction to the *Madhumalati*

(b) Pollock ed. *Literary Cultures in History*

(c) Orsini 'How to do multilingual literary history? Lessons from fifteenth- and sixteenth-century north India'

(d) Devy 'A Never Ending Transition'

Week 12 – Prose Readings (contd)
Week 13 – Prose Readings (contd)
Week 14 – Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Traditions
Multi-linguality
Syncreticism
Bhakti
Sufi

Sub-committee

Dhananjay Kapse Kirori Mal College (Coordinator)
Sheuli Chowdhury Kamla Nehru College
Shweta Sachdeva Jha Miranda House
Someshwar Sati Kirori Mal College
Yamini Dayal Singh College

PAPER D18

SPECULATIVE FICTION AND DETECTIVE LITERATURE

Semester 6

Course Statement

Since its emergence as a genre in the 19th century science fiction has sought to raise questions about the intervention of science and technology in human life. As its popularity grew many sub-genres emerged amongst these speculative fiction is significant for its exploration of what it means to be human even as it questions the shape possible futures may take and the fate of humanity in these possible futures. Detective fiction has even in its earliest forms investigated the category of crime and foregrounded the use of science and rationality in the decoding of crime. Through this course students are familiarized with both genres and explore the changing nature of crime and detection as well as issues of citizenship and bio-ethics through the prescribed readings.

Course Objectives

This course aims to

- investigate the categories of literature termed ‘speculative fiction’ and ‘detective literature’ and the accompanying social and philosophical issues associated with them
- help students engage with questions about the idea of ‘progress’ and the role of science and technology in human life and
- encourage students to explore the meaning of hitherto naturalized terms such as ‘crime’ and ‘human/humanity’.

Course Content

Unit 1

Margaret Atwood *The Handmaid’s Tale* (London: Vintage Books 1986 1996).

Unit 2

Kashigo Ishiguro *Never Let Me Go* (London: Faber and Faber 2005 2010).

Unit 3

a) Ibn-e-Safi *House of Fear* (New Delhi: Penguin Random House 2011).
b) Madulika Liddle *Crimson City* (Delhi: Hachette 2015).

Unit 4

Kathy Reichs *Bones Never Lie* (London: Arrow Books 2015).

Unit 5
Readings

a) Robert A. Heinlein 'On the Writing of Speculative Fiction online at
https://mab333.weebly.com/uploads/3/2/3/1/32314601/writing_sf_-_01_on_the_writing_of_speculative_ficiton.pdf
b) N. Katherine Hayles 'Towards Embodied Virtuality' in *How We Became Posthuman: Virtual Bodies in Cybernetics Literature and Informatics* (Chicago: University of Chicago Press 1999) pp. 1-24.
c) Donna Haraway'A Cyborg Manifesto: Science Technology and Socialist-Feminism in the Late Twentieth Century' in *Simians Cyborgs and Women: The Reinvention of Nature* (New York: Routledge 1991) pp. 149-181. (Online at http://www.stanford.edu/dept/HPS/Haraway/CyborgManifesto.html)
d) Charles J. Rzepka 'Introduction: What is Crime Fiction?' in Companion to Crime Fiction: Blackwell Companions to Literature and Culture eds Charles J Rzepka and Lee Horsley (Oxford: Wiley and Blackwell 2010) pp. 1-9.
e) Joy Palmer 'Tracing Bodies: Gender Genre and Forensic Detective Fiction' *South Central Review* Vol. 18 No. 3/4 *Whose Body: Recognizing Feminist Mystery and Detective Fiction* (Autumn-Winter 2001) pp. 54-71.

Teaching Plan
Paper D18: Speculative Fiction And Detective Literature

Week 1 – Introduction to Paper D18: Speculative Fiction and Detective Literature
Unit 5 – Heinlein and Hayles essays
Week 2 – Unit 1 -- Atwood: *A Handmaid's Tale*
Week 3 – Unit 1 (contd)
Week 4 – Unit 1 (contd)
Week 5 – Unit 1 (contd)

Week 6 – Unit 2 -- Haraway essay Ishiguro *Never Let Me Go*
Week 7 – Unit 2 (contd)
Week 8 – Unit 2 (contd)
Week 9 – Unit 3 -- Rezpka essay Ibn-e-Safi *House of Fear*
Week 10 -- Unit 3 (contd)
Week 11 – Unit 4 – Palmer essay Reichs *Bones Never Lie*
Week 12 – Unit 4 (contd)
Week 13 – Unit 4 (contd)
Week 14 – Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Spec-fic
Speculative fiction
Detective fiction
Forensics
Dystopia/Utopia
Bio-ethics in literature
Crime literature

Sub-committee

Sanam Khanna Kamala Nehru College (Coordinator)
Gorvika Miranda House College
Nidhi Bhandari Kamala Nehru College
Nitya Dutta Sri Venkateswara College

Shraddha A. Singh Zakir Hussain College
Shweta Sachdeva Jha Miranda House College

PAPER D19
STUDIES IN MODERN INDIAN PERFORMANCE TRADITIONS
Semester 6

Course Statement

The encounter between diverse popular performance traditions and colonial modernity evolved into distinct theatrical practices in twentieth century India. The plays included here are representative of this engagement within performative traditions and have a very strong bearing on the body-politic of modern India. The broad trends embodied here will illustrate the way in which theatre made sharp interventions in the socio-political scenario in India. The plays in this course range from the pre-Independence period to the present. They take into cognizance the popular folk and proscenium traditions in Indian theatre.

The period before independence is marked by Bijon Bhattacharya's *Nabanna*, seen as the defining moment in Indian theatre. It is the nucleus of a new kind of theatre at the level of form and content. Post-independence India is marked by varied theatrical formations. The proscenium theatre of Vijay Tendulkar exists alongside the more flexible Third theatre of Badal Sircar. The 1970s see a burst of theatrical activity with a special emphasis on street theatre. Jan Natya Manch's contribution with plays like *Aurat* are noteworthy. Tribal performance with a special focus on the Denotified Tribes (DNT) is presented in *Budhan*. The anxieties of post-Independence India form the focus in *Inquilab* and *Water*.

Course Objectives

This course aims to

- provide an overview of the varied performance traditions in modern India
- enable students to understand the significant mediations made by theatre at crucial moments in history
- show how each of the plays in this course functions as a historical marker bringing in new insights into an understanding of theatre and life and
- introduce the student to the dynamic structure of the street play.

Course Content

Unit 1

Bijon Bhattacharya *Nabanna* trans. Arjun Ghosh (New Delhi: Rupa 2018).

Unit 2

a) Jan Natya Manch 'Woman' ('Aurat') *Seagull Theatre Quarterly* Vol.16 pp. 23-24 1997
b) Badal Sircar'Procession' trans. Samik Bandyopadhyay Badal Sircar and Kalyani Ghose in
Three Plays: Procession Bhoma Stale News (Calcutta: Seagull 2009).

Unit 3

a) Asif Currimbhoy'Inquilab' in *The Bengal Trilogy: Inquilab The Refugee Sonar Bangla*
(Calcutta: Writers Workshop 1993).
b) Denotified Charras'Budhan' in *Painted Words: An Anthology of Tribal Literature* ed. G. N.
Devy (Vadodra: Purva Prakash 2012) pp. 243-73).

Unit 4

a) Vijay Tendulkar'Silence The Court is in Session' trans. Samik Bandyopadhyay in *Collected*
Plays in Translation (New Delhi OUP 2003).
b) Komal Swaminathan *Water* trans. S. Shankar (Calcutta: Seagull 1999).

Unit 5
Readings

a) Badal Sircar 'The Third Theatre' in *On Theatre* (Calcutta: Seagull 1999) pp. 1-18.
b) Utpal Dutt 'Innovation and Experimentation in Theatre' in *On Theatre* (Calcutta: Seagull
1999) pp. 53-63.
c) 'All India People's Theatre Conference Draft Resolution' in *People's Art in the Twentieth*
Century: Theory and Practice (New Delhi: Jan Natya Manch 2001) pp. 373-75.
d) Rustom Bharucha (i) 'Performance/Performativity/Theatre' (ii) 'Dangerous Liasions: Terror
and Performance' in *Terror and Performance*(New Delhi: Tulika 2014) pp. 19-29 29-32
(iii) 'The Indian People's Theatre Association' in *In the Name of the Secular: Contemporary*
Cultural Activism in India (Delhi: OUP) pp. 26-51.
e) Nemichandra Jain, 'Role of IPTA in Asides' *Themes in Contemporary Indian*

Theatre (New Delhi: NSD 2003) pp. 182-93.
f) K.A. Gunasekaran, 'Reflections on the Need for a Dalit Theatre' *JSL* Autumn 2006 Special
Issue on Theatre/Performance (New Delhi: JNU) pp. 76-81.

Teaching Plan
PAPER D19: Studies in Modern Indian Performance Traditions

Week 1 – Introduction to Paper 20: Studies in Modern Indian Performance Traditions
Week 2 – Unit 1 – Bhattacharya *Nabanna*
Week 3 – Unit 2 – Jan Natya Manch *Woman*
Week 4 – Unit 2 – Sircar 'Procession'
Week 5 – Sircar (contd)
Week 6 – Unit 3 -- Denotified Charras 'Budhan'
Week 7 – Unit 3 -- Currimbhoy 'Inquilab'
Week 8 – Unit 3 -- Denotified Charras 'Budhan'
Week 9 – Unit 4 – Tendulkar 'Silence the Court is in Session'
Week 10 -- Tendulkar (contd)
Week 11 – Unit 4 – Swaminathan *Water*
Week 12 – Unit 5 -- Prose Readings:
(a) Sircar 'The Third Theatre'
(b) Dutt 'Innovation and Experimentation in Theatre'
(c) All India People's Theatre Conference Draft Resolution
Week 13 – Prose Readings (contd):
(d) Bharucha 'Performance/ Performativity/ Theatre' 'Dangerous Liasions: Terror and Performance' 'The Indian People's Theatre Association'
(e) Jain 'Role of IPTA in Asides'
(f) Gunasekaran 'Reflections on the need for a Dalit Theatre'
Week 14 – Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions

2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Popular performance traditions
Colonial modernity
IPTA
Folk
Proscenium
Theatre and marginality

Sub-committee

Sanjay Kumar Hansraj College (Coordinator)
Anshuman Singh Dyal Singh College
Payal Nagpal Janki Devi Memorial College
Sachin N. Dyal Singh College
Sanjib Kumar Baishya Zakir Hussain College (Evening)
Vinod Verma Maharaja Agrasen College

PAPER D20
TWENTIETH CENTURY EUROPEAN FICTION
Semester 6

Course Statement

This is a new paper that partly extends the line of enquiry about the relationship between historical change and narrative forms. It emerges from a study of nineteenth century European realism into the twentieth century and partly looks at the emergence of new narrative experiments related to modernism and postmodernism in Europe. It engages with critical fictions that problematise and even undermine the idea of a unified Europe as the perceived cultural and political centre of the world since the period of the Enlightenment while also assessing the continuing impact of European forms of storytelling on literatures around the globe.

Course Objectives

This course aims to

- acquaint students with the main currents of fiction in twentieth-century Europe
- help develop an understanding of Europe as a cultural idea represented debated and questioned in the fictions of the twentieth century
- compare a variety of literary responses to the socio-political forces of change and ideologies that impinged on the lives of people in different regions of Europe in the twentieth century and
- allow the student to reflect on the situation of the European writer as a cultural spokesperson yet in a state of perpetual exile physically displaced and metaphorically distanced from the established centres of cultural power.

Course Content

Unit 1
Novellas
a) Franz Kafka *Metamorphosis* (1915) trans. Willa and Edwin Muir (New York: Vintage Classics 1992).
b) Albert Camus *The Stranger* (1942) trans. Matthew Ward (New York: Vintage Classics 1989).

Unit 2
Novel
Elfriede Jelinek *The Piano Teacher* (1983) trans. Joachim Neugroschel UK: Serpent's Tail Books 2010).

Unit 3
Novel
José Saramago *The Stone Raft* (1986) trans. Giovanni Pontiero (New York: Vintage Classics 2000).

Unit 4
Short Stories
a) Isaac Babel 'The Story of My Dovecoat' (1925) trans. Peter Constantine in *The Complete Works of Isaac Babel* (New York: W. W. Norton and Co. 2005) pp. 601-611.
b) Bruno Schulz 'The Street of Crocodiles' (1934) trans. Celina Wieniewska in *The Street of*

Crocodiles and Other Stories (UK: Penguin Classics 2008) pp. 63-72.
c) Ilse Aichinger 'The Bound Man' (1956) trans. Eric Mosbacher in *The Art of The Tale: An International Anthology of Short Stories* ed. Daniel Halpern (New York: Penguin 1986) pp. 10-17.
d) Natalia Ginzburg 'The Mother' (1963) trans. Isabel Quigly in *The Art of The Tale: An International Anthology of Short Stories* ed. Daniel Halpern (New York: Penguin 1986) pp. 23-34.

Unit 5
Prose Readings

a) Maurice Blanchot 'Reading Kafka' (1949) trans. Charlotte Mendel in *The Work of Fire* (California: Stanford University Press 1995) pp. 1-11.
b) Milan Kundera 'The Depreciated Legacy of Cervantes' (1984) trans. David Belos in *The Art of the Novel* (UK: Penguin 2004) pp. 3-20.
c) Tony Judt 'The Past is Another Country: Myth and Memory in Postwar Europe' *Daedalus* 121.4 (Fall 1992) pp. 83-118.
d) Zygmunt Bauman 'Dream of Purity' *Theoria* 86 (October 1995). pp. 49-60
e) Dubravka Ugrešić 'The Writer in Exile' (2010) in *In Exile* (e-published in Kitch Institute for art production and research Ljubljana 2007-2010) url: http://kitch.si/livingonaborder/node/1

Teaching Plan
Paper D20: Twentieth Century European Fiction

Week 1 – Introduction to Paper D20: Twentieth Century European Literature
Week 2 – Unit 1: Novellas
(a) Kafka *Metamorphosis*
(b) Camus *The Stranger*
Week 3 – Unit 1 (contd)
Week 4 – Unit 1 (contd)
Week 5 – Unit 2: Novel: Jelinek *The Piano Teacher*
Week 6 – Jelinek (contd)
Week 7 – Unit 3: Novel: Saramago *The Stone Raft*
Week 8 – Unit 3 (contd)
Week 9 – Unit 4: Short Stories

(a) Babel 'The Story of My Dovecoat'
(b) Schulz 'The Street of Crocodiles'
(c) Aichinger 'The Bound Man'
(d) Ginzburg 'The Mother'

Week 10 – Short Stories (contd)

Week 11 – Unit 5: Readings
(a) Blanchot 'Reading Kafka' (1949
(b) Kundera 'The Depreciated Legacy of Cervantes'
(c) Judt 'The Past is Another Country: Myth and Memory in Postwar Europe'
(d) Bauman 'Dream of Purity'
(e) Ugrešić 'The Writer in Exile'

Week 12 – Readings (contd)

Week 13 – Readings (contd)

Week 14 – Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2.	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3.	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Existentialism
War
Exile
Holocaust
Totalitarianism
Fascism
Resistance

Avant-Garde
Surrealism
Testimony
Dissidence
Repression
Iron Curtain
Postmodernism
European Union
Balkanisation

Sub-committee

Saikat Ghosh SGTB Khalsa College (Coordinator)
Dhananjay R. Kapse Kirori Mal College
Madhvi Zutshi SGTB Khalsa College
N. A. Jacob Ramjas College
Rudrashish Chakraborty Kirori Mal College
Shraddha Adityavir Singh Zakir Husain Delhi College
Advisors
Dr. Rimli Bhattacharya Dept. of English
Prof. Shaswati Mazumdar Dept. of Germanic and Romance Studies

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GENERIC ELECTIVE COURSE

PAPER G1: ACADEMIC WRITING AND COMPOSITION

Course Objectives

This course is designed to help undergraduate students develop the research composition argument and writing skills that will enable them to improve their written abilities for higher studies and academic endeavours

Unit 1
Introduction to the Writing Process

Unit 2
Introduction to the Conventions of Academic Writing

Unit 3
Writing in one's own words: Summarizing and Paraphrasing

Unit 4

Critical Thinking: Syntheses Analyses and Evaluation

Unit 5

Structuring an Argument: Introduction Interjection and Conclusion

Unit 6

Citing Resources Editing Book and Media Review

Week-wise teaching plan:

Week 1 - Unit 1-- Introduction to the writing process
Week 2- Unit 2 – Introduction to the conventions of academic writing
Week 3 - Unit 3 -- Writing in one's own words: summarizing and paraphrasing
Week 4 - Unit 3 Continued
Week 5 - Unit 4 -- Critical thinking: syntheses analyses and evaluation
Week 6 - Unit 4 Continued
Week 7 - Unit 4 Continued
Week 8 - Unit 4 Continued
Week 9 - Unit 5 -- Structuring an argument: introduction interjection and conclusion
Week 10 - Unit 5 Continued
Week 11 - Unit 5 Continued
Week 12 - Unit 6- Citing resources editing book and media review
Week 13 - Unit 6 Continued
Week 14 - Concluding lectures exam issues etc

Suggested Readings

1 Liz Hamp-Lyons and Ben Heasley *Study Writing: A Course in Writing Skills for Academic Purposes* (Cambridge: CUP 2006)

2 Renu Gupta *A Course in Academic Writing* (New Delhi: Orient BlackSwan 2010)

3 IlonaLeki *Academic Writing: Exploring Processes and Strategies* (New York: CUP 2nd edn 1998)

4 Gerald Graff and Cathy Birkenstein *They Say/I Say: The Moves That Matter in Academic Writing* (New York: Norton 2009)

5 Anjana Neira Dev *Academic Writing and Composition* New Delhi: Pinnacle 2015

Facilitating the Achievement of Course Learning Outcomes

SlNo	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in	Reading material together in small groups initiating

		small groups in Tutorial classes	discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Formal and informal writing
Writing process
Summary
Paraphrase
Note making
Editing
Citation
Plagiarism
Bibliography

Committee members

Madhumita Chakraborty Zakir Husain Delhi College Evening -- Coordinator
Debdulal Halder Kirorimal College
Satarupa Sinha Gargi College
Sanam Khanna Kamla Nehru College
Anjana Neira Dev Gargi college
Sameer Chopra Gargi College

PAPER G2: MEDIA AND COMMUNICATION SKILLS

Course Objectives

This is an introductory course in the role of media today – India and globally It will equip students with the basic theories on various aspects of media and impart training in basic writing skills required in the profession

Unit 1
Introduction to Mass Communication

a) Mass Communication and Globalization
b) Forms of Mass Communication

Topics for Student Presentations:

a) Case studies on current issues Indian journalism
b) Performing street plays
c) Writing pamphlets and posters etc.

Unit 2
Advertisement

a) Types of advertisements
b) Advertising ethics
c) How to create advertisements/storyboards

Topics for Student Presentations:

a) Creating an advertisement/visualization
b) Enacting an advertisement in a group
c) Creating jingles and taglines

Unit 3
Media Writing

a) Scriptwriting for TV and Radio
b) Writing News Reports and Editorials
c) Editing for Print and Online Media

Topics for Student Presentations:

a) Script writing for a TV news/panel discussion/radio programme/hosting radio programmes on community radio
b) Writing news reports/book reviews/film reviews/TV program reviews/interviews
c) Editing articles
d) Writing an editorial on a topical subject

Unit 4
Introduction to Cyber Media and Social Media

a) Types of Social Media
b) The Impact of Social Media

c) Introduction to Cyber Media

Week-wise teaching plan:

Week 1: Introduction to mass communication and media
Week 2: Unit 1 – Mass Communication and globalization
Week 3: Unit 1 continued -- Forms of mass communication
Week 4: Unit 2 – Forms of advertisement
Week 5: Unit 2 – continued
Week 6: Unit 2 – continued
Week 7: Unit 3 – Media writing
Week 8: Unit 3 – Media writing continued
Week 9: Unit 3 – Media writing continued
Week 10: Unit 3 – Media writing continued
Week 11: Unit 4 – Introduction to cyber media
Week 12: Unit 4 – Introduction to cyber media continued
Week 13: Class presentations
Week 14: Concluding lectures and exam preparations

Suggested readings

Media and Mass Communication:

1 MV Kamath*Professional Journalism* New Delhi: Vikas Publishing House 1980
2 Denis Macquail*Mass Communication* New Delhi: Om Books 2000
3 Ambrish Saxena*Fundamentals of Reporting and Editing* New Delhi: Kanishka Publishers 2007
4 MK Joseph*Outline of Editing* New Delhi: Anmol Publications 2002
5 TJS George*Editing: A Handbook for Journalists* (IIMC)
6 Harold Evans*Essential English for Journalists Editors and Writers* UK: Random House 2000
7 Rajiv Batra John G Myers David A Aaker*Advertising Management* (New Delhi Pearson Education
2007
8Em Griffin *Communication :A First Look at Communication Theory* Edition VIII McGraw Hill 2011
9Uma Narula *Handbook of Communication Models: Perspectives Strategies* New Delhi: Atlantic
Publishers 2006
10Jan Servaes ed*Communication for Development and Social Change* 2003 New Delhi: Sage India
2007
11Larry Barker *Communication* Edition VIII Boston: McGraw Hill 2002 rpt 2009

12 Brent D Ruben and Lea P Stewart *Communication and Human Behaviour Edition V* Pearson 2005

Television Journalism:
1 Andrew Boyd *Broadcast Journalism: Techniques of Radio and Television News* 2000 Burlington: Focal Press 6 edition 2009
2 Robert Thompson Cindy Malone *The Broadcast Journalism Handbook: A Television News Survival Guide* Maryland: Rowman & Littlefield Publishers 2004
3 Mark W Hall Broadcast Journalism: *An Introduction to News Writing* Hastings House 1978
4 Stephen Cushion *Television Journalism* Sage Publications 2012
5 Tony Feldman *An Introduction to Digital Media* Taylor & Francis 2004
6 Brian Carroll *Writing for Digital Media* Taylor & Francis 2010
7 Paul Messaris and Lee Humphreys eds*Digital Media: Transformations in Human Communications* New York: Peter Lang Publishing 2006
8 Megan A Winget William Aspray *Digital Media: Technological and Social Challenges of the Interactive World* Lanham: Scarecrow Press 2011

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Mass media

Globalisation
Development journalism
Print
Audio-visual
Advertising
Social media
Writing skills

Committee members

Debdulal Halder Kirori Mal College -- Coordinator
Madhumita Chakraborty Zakir Husain Delhi College Evening
Hari Prasad Zakir Husain Delhi College Evening
Rudrashish Chakraborty Kirorimal College

PAPER G3: TEXT AND PERFORMANCE:INDIAN PERFORMANCE THEORIES AND PRACTICES

Course Objectives

This course on Text and Performance combines Indian theories of dramaturgy along with a practical understanding of the stage These range from the classical theories of *Rasa* to the more modern ones that emerged in the twentieth century It will acquaint the students with the rise of modern theatre in the pre and post-independence period in India while also familiarising them with folk theatrical traditions

Unit 1
Introduction

- Introduction to theories of Performance in India: Classical to Contemporary Colonial to Resistant Endorsement of existing structures to Radicalising our world
- Historical overview of Indian theatre from the ancient to the modern

Topics for Student Presentations:

a) Perspectives on theatre and performance
b) Historical development of theatrical forms
c) Folk traditions
d) IPTA
e) Post-independence radical Indian theatre

Unit 2
Popular Theatrical Forms and Practices

- Nautanki Jatra Tamasha Bhramyamaan Theatre Street Theatre Campus Theatre

Topics for Student Presentations:

a) On the different types of performative space in practice
b) Poetry reading elocution expressive gestures and choreographed movement

Unit 3
Theories of Drama

- Bharata

Topics for Student Presentations:

a) Acting short solo/ group performances followed by discussion and analysis with application of theoretical perspectives
b) *Rasa* theory

Unit 4
Theatrical Production

- Direction production stage props costume lighting backstage support

Topics for Student Presentations:

All aspects of production and performance recording archiving interviewing performers and data collection

Course Outcomes

- A performance of minimum thirty minutes using any one form of drama studied in this course
- Interview at least one theatre practitioner who has worked with Indian theatrical forms

Week-wise teaching plan:
Week 1 – Introduction to the GE course on Indian Performance Theories and Practices
Week 2 – Unit 1 Introduction
Week 3 – Unit 1 continued
Week 4 – Unit 2 --Popular Theatrical Forms and Practices
Week 5 – Unit 2 continued
Week 6 – Unit 2 continued

Week 7 – Unit 3-- Theories of Drama
Week 8 – Unit 3 continued
Week 9 – Unit 4 --Theatrical Production
Week 10 -- Unit 4 continued
Week 11 – Unit 5 -- Field work: Interviewing a theatre practitioner
Week 12 – Unit 5 -- Working towards a Performance
Week 13 – Unit 5 continued
Week 14 – Concluding lectures exam issues etc

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords
Bharata
Rasa
Jatra
Nautanki
Tamasha
Street theatre
Campus theatre
Direction
Production
Stage props
Costume
Lighting
Backstage support

Committee members

Sanjay Kumar, Hansraj College -- Coordinator
Payal Nagpal, Janki Devi Memorial College

Sanjib Kumar, Baishya Zakir Husain Delhi College Evening
Anas Tabraiz, Zakir Husain Delhi College Evening
Anuradha Marwah, Zakir Husain Delhi College

PAPER G4: LANGUAGE AND LINGUISTICS

Course Objectives

To introduce and familiarize students with the basic concepts of language and linguistic theories

Unit 1
Language: language and communication language varieties: standard and non-standard language language change

Mesthrie Rajend and Rakesh M Bhatt 2008 *World Englishes: The study of new linguistic varieties*
Cambridge: Cambridge University Press

Unit 2
Structuralism

De Saussure Ferdinand 1966 *Course in general linguistics* New York: McGraw Hill Introduction: Chapter
3

Unit 3
Phonology and Morphology

Akmajian A R A Demers and R M Harnish *Linguistics: An Introduction to Language and Communication*
2nd ed
Fromkin V and R Rodman *An Introduction to Language* 2nd ed (New York: Holt Rinehart and Winston
1974) Chapters 3 6 and 7

Unit 4
Syntax and semantics: categories and constituents phrase structure maxims of conversation

Akmajian A R A Demers and R M Harnish Linguistics: An Introduction to Language and Communication
2nd ed (Cambridge Mass: MIT Press 1984 Indian edition Prentice Hall 1991) Chapter 5 and 6

Week-wise teaching plan

Week 1 – Unit 1 -- Introduction to linguistics
Week 2 – Unit 1 continued
Week 3 – Unit 1 continued
Week 4 – Unit 2
Week 5 – Unit 2 continued
Week 6 – Unit 2 continued
Week 7 – Unit 3
Week 8 – Unit 3 continued
Week 9 – Unit 3 continued
Week 10 – Unit 4
Week 11 – Unit 4 continued
Week 12 – Unit 4 continued
Week 13 – Final summing up
Week 14 – Discussions and exam preparations etc

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Language
Communciation
Linguistics
Structuralism
Morphology
Semantics

Committee members

Anjana Neira Dev, Gargi college-- Coordinator
Sameer Chopra, Gargi College
Abdullah Abdul Hameed

PAPER G5: READINGS ON INDIAN DIVERSITIES AND LITERARY MOVEMENTS

Course Objectives

This course seeks to equip students with an overview of the development of literatures in India and its wide linguistic diversity Students will study authors and movements from different regions and time periods

Sukrita Paul Kumar et al eds*Cultural Diversity Linguistic Plurality and Literary Traditions in India* New
Delhi: Macmillan 2005 Editorial Board: Department of English University of Delhi

Unit 1
This unit is compulsory
Any 6 of remaining 7 Chapters to be covered in the classroom

Unit 1
Overview

Unit 2
Linguistic Plurality within Sufi and Bhakti Tradition

Unit 3
Language Politics: Hindi and Urdu

Unit 4
Tribal Verse

Unit 5
Dalit Voices

Unit 6
Writing in English

Unit 7
Woman Speak: Examples from Kannada and Bangla

Unit 8
Literary Cultures: Gujarati and Sindhi

Week-wise teaching plan

Week 1 – Unit 1 -- Overview
Week 2 – Unit 1 continued
Week 3 – Unit 2 -- Linguistic Plurality within Sufi and Bhakti Tradition
Week 4 – Unit 2 continued
Week 5 – Unit 3 -- Language Politics: Hindi and Urdu
Week 6 – Unit 3 continued
Week 7 – Unit 4 -- Tribal Verse
Week 8 –- Unit 4 continued
Week 9 – Unit 5 -- Dalit Voices
Week 10 –- Unit 6 -- Writing in English
Week 11 – Unit 6 continued
Week 12 -- Unit 7 -- Woman speak: Examples from Kannada and Bangla/ Unit 8: Literary Cultures: Gujarati
and Sindhi
Week 13 – Selected Unit: continued
Week 14 – Concluding lectures discussion on exam pattern etc

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Cultural diversity
Indian languages
Sufi and Bhakti movements

Oral literature
Indian literary traditions
Tribal literature
Indian literatures
Indian literature in english
Indian literature in translation

Committee members

Sanam Khanna, Kamala Nehru College – Coordinator
Mithuraaj Dhusiya, Hansraj College
Anjana Neira, Dev Gargi college
Chaity Das, Kalindi College

PAPER G6: CONTEMPORARY INDIA: WOMEN AND EMPOWERMENT

Course Objectives

This course engages with contemporary representations of women femininities, gender-parity and power The course aims to help students from non-English literature backgrounds to develop a robust understanding of how discourses of gender underlie and shape our very lives experiences emotions and choices The courseexposes students to a broad range of literary and textual materials from various historical periods and contexts so that they are able to examine the socially-constructed nature of gendering Through analysing literary texts humanities and social sciences scholarship students will develop a nuanced understanding of how to perceive, read, understand, interpret and intervene ethically in debates on the subject

The course will help students:

- Read understand and examine closely narratives that seek to represent women femininities and by extension gendering itself
- Understand how gender norms intersect with other norms such as those of caste race religious and community to create further specific forms of privilege and oppression
- Identify how gendered practices influence and shape knowledge production and circulation of such knowledges including legal sociological and scientific discourses
- Participate in challenging gendered practices that reinforce discrimination
- Create a portfolio of analytical work (interpretations and readings of literary and social-sciences texts) and analyses of fictional and non-fictional narratives that students encounter in their lived worlds

Unit 1
Concepts

- Sex and Gender social construction of gender socialisation into gender
- Femininities and masculinities normative gender privilege heteronormativity
- Patriarchy: history of the term efforts to undo it feminism

Readings:

Rassundari Devi From Amar JibanWomen Writing in India: 600 BC to the early twentieth century Eds Susie Tharu and K Lalitha Delhi: OUP 1997 Pp 190—202
Rokeya Shekhawat Hossain 'Sultana's Dream'Women Writing in India: 600 BC to the early twentieth
century Eds Susie Tharu and K Lalitha Delhi: OUP 1997 Pp 340-351
Baby Kamble 'Our Wretched Lives'Women Writing in India: The twentieth century Eds Susie Tharu and
K Lalitha Delhi: OUP 1997 Pp 307-11
V Geetha *Patriarchy* Theorizing Gender Series Kolkata: Stree 2007 Pp 3—61

Unit 2
Intersections

- Women and caste religion class sexualities race disability
- Women and environment technology development
- Women and access to resources: employment health nutrition education
- Women and reproductive work: singleness marriage motherhood (symbolical biological surrogacy and ART) parenting abortion and other rights over own body

Readings:

Mahaweta Devi 'Bayen'*Five Plays* Trans Samik Bandyopadhyaya Calcutta: Seagull 2009
Mary John 'Feminism Poverty and the Emergent Social Order' in *Handbook of Gender*ed Raka Ray Delhi:
Oxford University Press 2012
Leela Kasturi 'Report of the Sub-Committee Women's Role in Planned Economy National Planning
Committee (1947) in Maitrayee Chaudhuri ed*Feminism in* India Delhi: Zed 2005 pp 136-155
Vandana Shiva *Staying Alive: Women Ecology and Development* Chapters 2&4 Delhi: Kali for Women
1989
M M Vinodini 'The Parable of the Lost Daughter' in The Exercise of Freedom Eds K Satyanarayana and
Susie Tharu Delhi: Navayana 2013 Pp 164-77

Unit 3
Histories

- The women's question pre-Independence: sati-reform widow remarriage debates around age of consent
- Women in the Independence movement Partition
- Post-Independence campaigns against sexual harassment and rape dowry violence debates around the Uniform Civil Code
- Public sphere participation of women: in politics in the workplace in the economy creating educational inclusion

Readings:

Radha Kumar A History of Doing: An Illustrated Account of Movements for Women's Rights and Feminism in India 1800—1990 Chapters 2 3 7 8 11 Delhi Zubaan 1993

Kumkum Sangari 'Politics of Diversity: Religious Communities and Multiple Patriarchies'*Economic and Political Weekly* 3052 (1995)

Tanika Sarkar 'Rhetoric against Age of Consent-Resisting Colonial Reason and Death of a Child-Wife' *Economic and Political Weekly* 2836 (1993 April)

Urvashi Butalia Chapter 2 'Blood'*The Other Side of Silence: Voices from the Partition of India* Delhi: Penguin Books 1998

Urmila Pawarand MeenakshiMoon *We also made history: Women in the Ambedkarite Movement* Chs 1 5 6 Delhi: Zubaan: 2008

Unit 4
Women, the Law, the State

- Constitutional remedies and rights against gender-based violence
- The history of constitutional protections for women (Hindu Code Bill right to property personal laws)
- State interventions and feminist engagement with the law
- IPC sections relevant to rape protection of 'modesty' of women obscenity
- The concept of 'woman' in these frameworks

Readings:

Janaki Nair('The Foundations of Modern Legal Structures in India') and Flavia Agnes ('Conjugality
Property Morality and Maintenance') in *Handbook of Gender* Ed Raka Ray Delhi: OUP 2012

Workshop: Students to examine the bare text of 4 laws (as set out in the Gazette of India) followed by discussion and analysis: laws against dowry (The Dowry Prohibition Act 1961) against sex determination (Pre-Conception & Pre-Natal Diagnostics Act 1994) against domestic violence (Protection of Women from Domestic Violence Act 2005) against sexual harassment at the workplace (The Sexual Harassment of Women at Workplace Prevention Prohibition and Redressal Act 2013)

Week-wise teaching plan

Week 1: Unit 1 -- Concepts
Week 2: Unit 1 continued
Week 3: Unit 1 continued
Week 4: Unit 2 -- Intersections
Week 5: Unit 2 continued
Week 6: Unit 2 continued
Week 7: Unit 2 continued
Week 8: Unit 3 -- Histories
Week 9: Unit 3 continued
Week 10: Unit 3 continued
Week 11: Unit 3 continued
Week 12: Unit 4 -- Women the Law the State
Week 13: Unit 4 continued
Week 14: Unit 4 continued

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual	Discussing exam questions and	Class tests

	understanding in tests and exams	answering techniques	

Keywords

Gender
History
Law
Caste
Femininities
Masculinities
Heteronormativity
Patriarchy
Feminism
Gender-based violence
Casteism
Women's movements

Revision committee members

Brati Biswas, Dyal Singh Evening College -- Coordinator
Aneeta Rajendran, Gargi College
Mudita Mohile, Gargi College
Rajendra Parihar, Ramjas College

PAPER G7: LANGUAGE LITERATURE AND CULTURE

Course Objective

This course is designed to introduce the students with the basic concepts of language its characteristics its structure and how it functions The course further aims to familiarise the students how language is influenced by the socio-political-economic-cultural realities of the society It also wants to acquaint the students about the relation between language and literature.

Course Content

Unit 1
Language

A -- Language and Communication
- o What is Language?
- o The Definition of Language
- o The Characteristics of Human language
- o Why Does Language Matter?

B -- How Language Functions?
  a. Speaker – Listener – Message
  b. Phonology Morphology Syntax and Semantics
     (only terms and definitions will be asked)

- Phonemes, phonetic transcription and phonology
- Morphemes: free and bound morphemes
- Simple complex compound words
- Inflectional/ derivational morphology
- The process of word formation
- Basic notions of syntactic constituents and phrase structure
- Clauses and sentences

C -- Language and Society

- Language and Class Language and
- Gender Language and Ethnicity
- Language and Identity
- Language Variation
    a. Dialect Idiolect Slang Pidgin Creole Jargon
    b. Standard and Non-Standard Language
    c. Bilingualism Multilingulism
    d. Code-mixing Code-switching

Bibliography

1. Fowler, Roger (ed) *Essay on Style and Language* London: Routledge and Kegan Paul Ltd 1966
2. Fowler, Roger *The Linguistics of Literature* London: Routledge and Kegan Paul Ltd 1971
3. Widdowson, H G *Stylistics and the Teaching of Literature* London: Longman 1979
4. Bailey, R W and J L Robinson eds *Varieties of present-day English* New York: Macmillan 1973
5. Fishman, J A *Sociolinguistics: A Brief Introduction* Mass: Newbury House Rowley 1971
6. Gupta, R S and K S Agarwal *Studies in Indian Sociolinguistics* New Delhi: Creative Books 1996
7. Hudson, R A *Sociolinguistics* Cambridge: Cambridge University Press 1980
8. Leech, Geoffrey and Michael Short Style in Fiction London: Longman 1981

Unit 2
Indian Literature

This section of the course will involve a study of significant themes and forms of Indian literature through the ages with the help of prescribed texts

Prescribed text*: Indian Literature: An Introduction* University of Delhi: Delhi 2005

Different Phases of Indian literatures: Ancient Medieval and Modern

Chapter 1: Veda Vyasa, The *Mahabharata*: The Ekalavya Episode
Chapter 2: Sudraka, *Mrichchhakatika*: The Making of a Breach
Chapter 3: Ilanko Atikal, *Cilappatikaram*: The Book of Mathurai

Chapter 4: Mirabai,'I Know Only Krsna'
Chapter 5: Amir Abul Hasan Khusrau,'Separation'
Chapter 6: Asadullah Khan Ghalib,'Desires Come by the Thousands'
Chapter 7: Faiz Ahmad Faiz,'Do Not Ask'
Chapter 8: Subramania Bharati,'The Palla Song'
Chapter 9: Rabindranath Tagore, 'The Cabuliwallah'
Chapter 10: Shrilal Shukla,'Raag Darbari'
Chapter 11: Ismat Chugtai,'Touch-Me-Not'
Chapter 12: Amrita Pritam,'To Waris Shah'
Chapter 13: Masti Venkatesha Iyengar,'Venkatashami's Love Affair'
Chapter 14: Indira Goswami,'The Journey'
Chapter 15: Omprakash Valmiki,'Joothan'
Chapter 16 Shrikant Mahapatra, Folk Songs

Further Reading

Sisir Kumar Das ed *A History of Indian Literature* New Delhi: Sahitya Akademi 1995

Unit 3

Culture and Society in Contemporary India

(i) The Idea of Culture
(ii) Culture and the Media

a) 'Notes on the History of the Study of the Indian Society and Culture' in *Structure and Change in Indian Society* ed Milton Singer and Bernard S Cohn (Chicago: Aldine Press1968)
b) 'Towards a Definition of Culture' in *India and World Culture*(New Delhi: Sahitya Academy 1986
c) 'Culture and Ideology' in *Culture Ideology and Hegemony: Intellectual and Social Consciousness in Colonial India* (Practice London and New York: Longman 1995
d) *Communications and Culture* ed MR Dua Delhi: Galgotia Publishing Co 1997
e) *Journalism: Changing Society Emerging Trends* Delhi Authorspeak 2003

Week-wise teaching plan
Week 1: Overview and introduction
Week 2: Unit 1 – Language
Week 3: Unit 1 continued
Week 4: Unit 1 continued
Week 5: Unit 2 – Literature – Chapters 1 and 2
Week 6: Unit 2 continued – Chapters 3 and 4
Week 7: Unit 2 continued – Chapters 5 and 6
Week 8: Unit 2 continued -- Chapters 7 and 8
Week 9: Unit 2 continued -- Chapters 9 and 10
Week 10: Unit 2 continued – Chapters 11 and 12
Week 11: Unit 2 continued – Chapters 13 and 14
Week 12: Unit 2 continued – Chapters 15 and 16

Week 13: Unit 3 -- Culture
Week 14: Culture and concluding lectures

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Language
Indian literature
Literary diversity
Language varieties
Culture
Literature and culture
Culture and practice
Globalisation

Committee members
Vandana Agarwal, PGDAV College -- Coordinator
Dhananjay Kapse, Kirorimal College
Shatarupa Sinha, Gargi College
Sanam Khanna, Kamla Nehru College

PAPER G8: GRAPHIC NARRATIVES

Course Objectives

The graphic narrative in long form is today a prominent and popular mode in visual cultures its accessibility making it often the first entry point to the world of literature for many young people As a form it has been omnivorous in providing representation to both dominant hegemonic values as well as subversive ones The best examples of the form work through the interconnection of art and text the intersection of drawing coloured and blank spaces proportion and pithy dialogue

This course aims to:

- introduce graphic narrative to students of non-literary studies backgrounds
- provide a toolkit for them to acquire visual literacy and thus to equip them to better understand popular public cultures
- examine how major graphic narrative comment on contemporary culture history and mythology
- provide visual literacy tools through examining visual arts as extending translating and providing a new textual vocabulary to narrative including fictional and non-fictional narrative
- provide exposure to major genres within the field such as that of the mass-circulation 'comic' book the fictionalized autobiography/memoir biographical texts and that of fiction
- provide tools for the exploration of form and genre that are sensitive to nuances of race gender caste ethnicity ableism and sexuality
- enable students from backgrounds in subjects other than English literary studies to broaden their skill-sets in textual interpretation reading and writing about texts

Course Contents

Unit 1

George Remi,*The Adventures of Tintin: Red Rackham's Treasure* UK: Egmont 2013 (1943) and Goscinny

Rene and Uderzo Albert *Asterix and Cleopatra* Delhi: Hachette 2015 (1963)

Unit 2

Marjane Satrapi,*Persepolis*(London: Vintage, 2008 [2003])

Unit 3

Amruta Patil,*Kari*(Delhi: Harper Collins, 2008)

Unit 4

Srividya Natarajanand Aparajita Ninan, *A Gardener in the Wasteland* (Delhi: Navayana, 2016)

Week-wise teaching plan

Week 1: Unit 1 --*The Adventures of Tintin: Red Rackham's Treasure*
Week 2: Unit 1 continued – *The Adventures of Tintin: Red Rackham's Treasure*
Week 3: Unit 1 continued --*Asterix and Cleopatra*
Week 4: Unit 1 continued --*Asterix and Cleopatra*

Week 5: Unit 2 --*Persepolis*
Week 6: Unit 2 continued --*Persepolis*
Week 7: Unit 2 continued --*Persepolis*
Week 8: Unit 2 continued --*Persepolis* to be completed; begin Unit 3 --*Kari*
Week 9: Unit 3 -- *Kari*
Week 10: Unit 3 continued --*Kari*
Week 11: Unit 3 continued -- *Kari* to be completed; begin Unit 4 --*A Gardener in the Wasteland*
Week 12: Unit4 -- *A Gardener in the Wasteland*
Week 13: Unit4continued -- *A Gardener in the Wasteland*
Week 14: Unit4 continued --*A Gardener in the Wasteland*

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Visual literacy
Popular public cultures
Visual arts
Narrative
Interpretation and reading

Committee members

Aneeta Rajendran, Gargi College -- Coordinator
Gorvika Rao, Miranda House
Mukul Chaturvedi, Zakir Husain Delhi College
Rina Ramdev, Sri Venkateswara College

Amrita Singh, Kamla Nehru College
Shweta Sachdeva Jha,Miranda House

PAPER G9: CINEMATIC ADAPTATIONS OF LITERARY TEXTS

Course Objectives

This paper will equip students from non-English studies backgrounds to explore the language of cinema through their study of a canonical literary text The study of global film adaptations of Shakespeare's *Othello* will focalize this paper's examination of theories of adaptation transformation and transposition

- Students will engage with the relationship between text and filmand examine the contexts of film production in global film industries including Hollywood and Bollywood
- As an elective English studies paper the core focus is textual study and interpretative work wherein the student gains skills in studying Shakespeare as much as the language of film via appreciation of its specific features as a medium
- Focus on reception and critical work and history through the comparative framework to examine the different contexts of production of the play and the films

Course Contents

Unit 1
The Language of Cinema

James Monaco ‘The Language of Film: Signs snd Syntax’ in *How to Read a Film: The World of Movies Media & Multimedia* (New York: OUP, 2009) Chap. 3, pp. 170–249.
Stam Robert, ‘Beyond Fidelity: The Dialogues of Adaptation’ in James Naremore, ed.,*Film Adaptation* (New Brunswick, NJ: Rutgers University Press, 2000)pp. 54-76.

Unit 2

Shakespeare, *Othello* (play)

Unit 3

Othello (movie, dir. Stuart Burge, 1965)

Unit 4

Othello (movie, dir. Oliver Parker, 1995)

Unit 5

Omkara (movie, dir. Vishal Bhardwaj, 2006)

Suggested films:

Pinjar (dir. Chandra Prakash Dwivedi, 2003) - Hindi
Ghare Baire (dir. Satyajit Ray, 1984) - Bangla
Kaliyattam (dir. Jayaraaj, 1997) - Malayalam

Suggested readings:

Andre Bazin, 'Adaptation or the Cinema as Digest', in Film and Literature: An Introduction and Reader, ed.
Timothy Corrigan, pp. 57-64.
Linda Hutcheon,'On the Art of Adaptation',*Daedalus* Vol. 133 (2004)

Week-wise teaching plan

Week 1 -- Unit 1 -- The Language of Cinema
a) James Monaco, 'The Language of Film: Signs snd Syntax'
b) Stam Robert, 'Beyond Fidelity: The Dialogues of Adaptation'
Week 2 – Unit 1 continued
Week 3 – Unit 1 continued
Week 4 – Unit 2 -- *Othello* (Shakespeare)
Week 5 – Unit 2 continued
Week 6 – Unit 3 --*Othello* (1965 dir. Stuart Burger)
Week 7 – Unit 3 continued
Week 8 – Unit 3 continued
Week 9 – Unit 4 --*Othello* (1995 dir. Oliver Parker)
Week 10 – Unit 4 continued
Week 11 – Unit 4 continued
Week 12 – Unit 5 --*Omkara* (2006 dir. Vishal Bhardwaj)
Week 13 – Unit 5 continued
Week 14 – Unit 5 continued

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in	Reading material together in small groups initiating

		small groups in Tutorial classes	discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Literature
Cinema
Text
Language
Adaptation
Transformation
Transposition

Committee members

Sachin N, Dyal Singh College – Coordinator
Mithuraaj Dhusiya, Hansraj College
Krishnan UnniP, Deshbandhu College
Dhananjay Kapse, Kirorimal College
Gorvika Rao, Miranda House
Sakshi Dogra, Gargi College

PAPER G10: INDIAN ENGLISH LITERATURES

Course Objectives

Over the past two centuries, especially after the 1980s, Indian writing in English has emerged as a major contribution to Indian as well as global literary production A close analysis of some of the major works of Indian Writing in English is crucial in any exploration of modern Indian subjectivities histories and politics.

• The paper intends to introduce students to Indian English Literature and its oeuvre through the selected literary texts across genres
• It further aims to enable the students to place these texts within the discourse of postcoloniality and understand Indian literary productions in English in relation to the hegemonic processes of colonialism neo-colonialism nationalism and globalisation

• The paper also hopes to allow the students to situate this corpus within its various historical and ideological contexts and approach the study of Indian Writing in English from the perspectives of multiple Indian subjectivities

Unit 1

RK Narayan,*Swami and Friends*

Unit 2

Firdaus Kanga,*Trying to Grow*

Unit 3

Mahesh Dattani,*Tara*

Unit 4

Shashi Deshpande,'The Intrusion'
Salman Rushdie,'The Courter'
Rohinton Mistry,'Swimming Lessons'
Vikram Chandra,'Dharma'

Unit 5

Kamala Das,'An Introduction','My Grandmother's House'
Nissim Ezekiel,'Night of the Scorpion','Goodbye Party for Miss Pushpa TS'
Arun Kolatkar,'The Bus','A Low Temple'
Vikram Seth,'The Crocodile and the Monkey'
Mamang Dai,'The Sorrow of Women'

Week-wise teaching plan

Week 1: Introduction to the Paper: Indian Writing in English
Week 2: Unit 1 – Narayan,*Swami and Friends*
Week 3: Unit 1 continued
Week 4: Unit 1 continued
Week 5: Unit 2 – Kanga,*Trying to Grow*
Week 6: Unit 2 continued
Week 7: Unit 2 continued
Week 8: Unit 3 – Dattani,*Tara*
Week 9: Unit 3 continued
Week 10: Unit 4 – Deshpande,'The Intrusion'; Rushdie,'The Courter'
Week11: Unit 4 – Mistry,'Swimming Lessons';Chandra,'Dharma'
Week 12: Unit 5 – Das,'An Introduction','My Grandmother's House'; Ezekiel 'Night of the Scorpion', 'Goodbye Party for Miss Pushpa TS'
Week 13: Unit 5 – Kolatkar,'The Bus','A Low Temple'; Seth,'The Crocodile and the Monkey'; Dai, 'The Sorrow of Women'

Week 14: Concluding lectures and course queries

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Indian novel
Imagery in Indian poetry
Diaspora
Self and society

Committee members

Someshwar Sati, Kirorimal College – Coordinator
DhananjayKapse, Kirorimal College
Karuna Rajeev, Lady Shri Ram College for Women
Rohith P, Deen Dayal Upadhyaya College
Viraj Kafle, Dyal Singh College (Morning)

PAPER G11: POPULAR FICTION

Course Objectives

The paper engages with issues surrounding the category termed ‘popular literature’. Questions about the roles of readership bestsellers and the role of mass market publication are explored. Various genres, such as writing for children and young adults, detective fiction, and modern mythology, which are considered popular, are included here. The paper aims at promoting an understanding of popular literature as a socially relevant and pleasurable form of writing which engages with contemporary issues

- Through this paper students will be brought to question the categories of 'high' and 'low' literature and issues concerning 'popular culture'.
- Students will explore the social and cultural relevance of popular texts and bestsellers as products of their time and age which mirror the aspirations and anxieties of the society and class of their readership.

Course Contents

Unit 1

Ruskin Bond, *The Blue Umbrella*

Unit 2

Amish, *The Immortals of Meluha*

Unit 3

Alexander McCall Smith,*The No 1 Ladies Detective Agency*

Unit 4

John Green, *Paper Towns*

Week-wise teaching plan

Week 1 – Unit 1 -- Introduction and Bond, *The Blue Umbrella*
Week 2 – Unit 1 continued
Week 3 – Unit 1 continued
Week 4 – Unit 2 – Amish, *The Immortals of Meluha*
Week 5 – Unit 2 continued
Week 6 – Unit 2 continued
Week 7 – Unit 2 continued
Week 8 -- Unit 3 – Smith, *The No 1 Ladies Detective Agency*
Week 9 – Unit 3 continued
Week 10 -- Unit 3 continued
Week 11 – Unit 4 – Green, *Paper Towns*
Week 12 -- Unit 4 continued
Week 13 – Unit 4 continued
Week 14 – Concluding lectures discussion on exam pattern etc

Facilitating the Achievement of Course Learning Outcomes

Sl	Course Learning	Teaching and	Assessment Tasks

No	Outcomes	Learning Activity	
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Popular fiction
Literary cultures
Genre fiction
Mass media
High and low literature
Literature and marketing

Committee members

Sanam Khanna, Kamala Nehru College – Coordinator
Shraddha Adityavir Singh, Zakir Husain Delhi College
Shweta Sachdeva Jha, Miranda House
Amrita Singh, Kamala Nehru College

PAPER G12: CULTURE AND THEORY

Course Objectives

This course presents key theories seminal to the development of culture in the twentieth century. It combines a theoretical base with its practical application to literature. It focuses on the construction of culture in society and its application to the simplest aspects of life. The literary texts have been selected carefully to comprehend the connections between culture, literature and life

Course Content

Unit 1

Antonio Gramsci, 'The Formation of the Intellectuals', and 'Hegemony (Civil Society) and the Separation of
Powers', in *Selections from the Prison Notebooks*, ed. and tr. Quentin Hoare and Geoffrey Novell Smith (London: Lawrence and Wishart 1971).

Short Story
Anton Chekhov,'The Bride',*Selected Works*(Moscow: Progress P, 1973).

Unit 2

Roland Barthes,'Novels and Children','Toys','Plastic', in*Culture* (London: Vintage, 2009).

Short Story
Thomas Mann,'Gladius Dei', in *Little Herr Friedmann and OtherStories*(Harmondsworth: Penguin, 1961).

Unit 3

Edward Said, 'The Scope of Orientalism', in *Orientalism* (Harmondsworth: Penguin, 1977) pp.31-73.

Short Story
Lu Xun,'My Old Home',*Selected Works*, Vol. 1 (Bejing: Foreign Languages Press, 1980).

Unit 4

Simone de Beauvoir,*The Second Sex* (London: Vintage 1997), Introduction, pp.13-29.

Short Story
Jean Paul Sartre,'Intimacy',*The Wall*, trans.(Alexander Lloyd Wisconsin: Hal Leonard Corp, 1995).

Unit 5

Michel Foucault,'What is an Author?', in*Modern Criticism and Theory: A Reader*, ed. David Lodge with
Nigel Wood (New Delhi: Pearson, 2007) pp. 192-205.

Short Story
Katherine Mansfield,'The Voyage', in *The Penguin Book of Short Stories*,ed. Christopher Dolley
(Harmondsworth: Penguin, rpt 1970)

Suggested Readings

Louis Althusser,'Ideology and Ideological State Apparatuses', in *Lenin and Philosophy and Other Essays*
(New Delhi: Aakar Books, 2006) pp. 85–126.
Roland Barthes 'Death of the Author' in*Modern Criticism and Theory: A Reader*, ed. David Lodge with
Nigel Wood (New Delhi: Pearson 2007) pp.164-68.
Kate Millett,'Instances of Sex' and 'Theory of Sexual Politics', in *Sexual Politics* (London: Rupert Hart-
Davis 1971) pp. 3-22; 23-58.
Michel Foucault 'Truth and Power', in*Power and Knowledge*, tr. Alessandro Fontana and Pasquale Pasquino
(New York: Pantheon 1977) pp. 109–33

Week-wise teaching plan

Week 1 – Introduction to GE,Paper 11: Culture and Theory
Week 2 – Unit 1 – Gramsci
Week 3 – Unit 1 continued -- Gramsci
Week 4 – Unit – 1 continued -- Chekov
Week 5 – Unit 2 – Barthes
Week 6 – Unit 2 continued – Mann,'Gladius Dei'
Week 7 – Unit 3 -- Edward Said
Week 8 – Unit 3 continued – Said;Xun 'My Old Home
Week 9 – Unit 3 continued -- Xun
Week 10 -- Unit 4 –de Beauvoir
Week 11 – Unit 4 continued – Sartre,'Intimacy'
Week 12 – Unit 5 -- Foucault
Week 13 – Unit 5 continued – Mansfield,'The Voyage'
Week 14 – Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual	Discussing exam questions and	Class tests

	understanding in tests and exams	answering techniques	

Keywords

Intellectuals
Hegemony
Culture
Orientalism
Author
Social conditioning
Feminist movement

Committee Members

Payal Nagpal, Janki Devi Memorial College -- Coordinator
Rudrashish Chakraborty, Kirorimal College
Anas Tabraiz, Zakir Husain Delhi College Evening
Mudita Mohile, Gargi College

PAPER G13: MARGINALISATIONS IN INDIAN WRITING

Course Objectives

Since the twentieth century,literary texts from varied contexts in India have opened up new discursive spaces from within which the idea of the normative is problematized. Positions of marginality, whether geographical, caste, gender, disability, or tribal, offer the need to interrogate the idea of the normative as well as constitutions of the canon. Though this engagement has been part of literary academic analysis, it has just begun making its foray into the syllabus of English Departments of Indian universities This paper hopes to introduce undergraduate students to perspectives within Indian writing that acquaint them with both experiences of marginalization, alongside with examining modes of literary stylistics that offer a variation from conventional practice

This paper intends to

- makeundergraduate students approach literature through the lens of varied identity positions and evolve in them a fresh critical perspective for reading literary representations
- enable them to explore various forms of literary representations of marginalisation as well as writing from outside what is the generally familiar terrain of Indian writing in schools
- make them aware of the different ways in which literary narratives are shaped, especially since some of the texts draw on traditions of the oral mythic folk and the form of life-narrative as stylistics

- make them understand how literature is used also to negotiate and interrogate this hegemony
- evolve an alternative conception of corporeal and subjective difference

Course Contents

Unit 1
Caste

BR Ambedkar,*Annihilation of Caste: The Annotated Critical Edition*, Chaps 4 (233-236) 6 (241-244) and 14
(259-263) (New Delhi: Navayana Publications, 2015).
Bama, *Sangati*,'Chapter 1', trans. Lakshmi Holmstrom(New Delhi: Oxford University Press, 2005) pp. 3-
14.
Ajay Navaria,'Yes Sir',*Unclaimed Terrain*, trans. Laura Brueck(New Delhi: Navayana, 2013) pp. 45-64.
Aruna Gogulamanda,'A Dalit Woman in the Land of Goddesses', in *First Post*, 13 August 2017.

Unit 2
Disability

Rabindranath Tagore,'Subha', *Rabindranath Tagore: The Ruined Nest and Other Stories*,trans. Mohammad
A Quayum(Kuala Lumpur: Silverfish, 2014)pp. 43-50.
Malini Chib,'Why Do You Want to Do BA',*One Little Finger*(New Delhi: Sage, 2011)pp. 49-82.
Raghuvir Sahay,'The Handicapped Caught in a Camera', trans. Harish Trivedi, *Chicago Review* 38: 1/2
(1992) pp. 146-7.
Girish Karnad,*Broken ImagesCollected Plays: Volume II*(New Delhi: Oxford University Press, 2005) pp.
261-84.

Unit 3
Tribe

Waharu Sonawane,'Literature and Adivasi Culture',*Lokayana Bulletin*, Special Issue on Tribal Identity, 10:
5/6 (March-June 1994): 11-20
Janil Kumar Brahma,'Orge', *Modern Bodo Short Stories*,trans. Joykanta Sarma (Delhi: Sahitya Akademi,
2003) pp. 1-9.
D. K.Sangma,'Song on Inauguration of a House', trans. Caroline Marak, *Garo Literature*(Delhi: Sahitya
Akademi, 2002) pp. 72-73.
Randhir Khare,'Raja Pantha',*The Singing Bow: Poems of the Bhil*(Delhi: Harper Collins, 2001) pp. 1-2.

Unit 4
Gender

Living Smile Vidya,'Accept me!' in *I Am Vidya: A Transgender's Journey* (New Delhi: Rupa, 2013)pp. 69-
79.

Rashid Jahan,'Woh', trans. M. T. Kahn, in *Women Writing in India 600 BC to the Present Vol 2*Susie
Tharu and K Lalita.eds(New York: The Feminist Press, 1993) pp. 119-22.

Ismat Chugtai,'Lihaf', trans. M. Assadudin,*Manushi*, Vol. 110, pp. 36-40.

Hoshang Merchant,'Poems for Vivan', in *Same Sex Love in India: Readings from Literature and History*,
Ruth Vanita and Saleem Kidwai,eds(New York: Palgrave, 2001) pp. 349-51.

Unit 5
North-East

Mamang Dai,'Myths of Creation',*Arunachal: A Hidden Land*(New Delhi: Penguin, 2009) pp. 37-50.

Cherrie L Chhangte,'What Does an Indian Look Like', Tilottoma Misra, ed., *The Oxford Anthology of*
Writings from North-East India: Poetry and Essays(New Delhi: Oxford UP, 2011) p. 49.

K. S.Nongkynrih,'Ren',*Anthology of Contemporary Poetry from the Northeast*,K. S. Nongkynrih and R. S.
Ngangom, eds(Shillong, India: NEHU Publications, 2003)pp.158-59.

IndiraGoswami,'The Offspring', trans. Indira Goswami,*Inner Line: The Zubaan Book of Stories by Indian*
Women,Urvashi Butalia, ed. (New Delhi: Zubaan, 2006)pp. 104-20.

Week-wise teaching plan

Week 1: Introduction to the paper through an understanding of marginality in Indian literary representations
and voices from positions of marginality and the political impetus of such writing
Week 2: Introduction continued
Week 3: Unit 1 -- Caste: Ambedkar, *Annihilation of Caste*; Bama'Ch1'*Sangati*
Week 4: 1 continued – Ajay,'Yes Sir'; Aruna,'A Dalit Woman in the Land of Goddesses'
Week 5: Unit2 -- Disability: Tagore'Subha';Chib, 'Why Do You Want to Do BA'
Week 6: Unit 2 continued -- Sahay, 'The Handicapped Caught in a Camera';Karnad,*Broken Images*
Week 7: Unit3 --Tribe: Sonawane,'Literature and Adivasi Culture'; Kumar,'Orge'
Week 8: Unit 3 continued – Sangma, 'Song on Inauguration of a House'; Khare,'Raja Pantha'

Week 9: Rubric 4: Gender: Vidya,'Accept me!';Jahan,'Woh'
Week 10: Unit 4 continued –Chughtai, 'Lihaf'; Merchant,'Poems for Vivan'
Week 11: Rubric 5 --North-East:Dai, 'Sorrows of Women';Chhangte, 'What does an Indian Look like'
Week 12: Unit 5 continued – Nongkynrih, 'Ren'; Goswami, 'The Offspring'
Week 13: (a) Engagement with the varied positions within the course and a consideration of literary
representations of the same; and(b) What close reading offers to both an understanding of narrative and the socio-political worlds from which texts emerge
Week 14: Concluding lectures and course queries

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Lived experience
Hegemony
Voice
Normative
Oppression
Self-assertion

Committee Members

Karuna Rajeev, Lady Shri Ram College for Women -- Coordinator
Someshwar Sati, Kirorimal College
B Mangalam, Aryabhatta College
Mukul Chaturvedi, Zakir Husain Delhi College

Rohith P, DeenDayalUpadhyaya College
Viraj Kafle, Dyal Singh College

PAPER G14: ***THE INDIVIDUAL AND SOCIETY***

Course Objective

This anthology introduces students to the various issues that face society today – caste, class, race, gender violence, and globalization It serves as an effective entry point to an understanding of these areas that students will encounter in their higher studies and daily lives, and aims to provide them with a holistic understanding of these issues and their complexities

Unit 1
Caste and Class

Chapters 1 2 3 4 56

Unit 2
Gender

Chapters 8 9 10 12 13 15

Unit 3
Race

Chapters 16 17 18 19

Unit 4
Violence and War

Chapters 22 23 25 26

Unit 5
Living In a globalized World

Chapters 29 31 32 34

Week-wise teaching plan

Week 1 – Unit 1-- Caste/Class
Week 2 – Unit 1 continued
Week 3 – Unit 1 continued
Week 4 – Unit 2 -- Gender
Week 5 – Unit 2 continued
Week 6 – Unit 2 continued
Week 7 – Unit 2 continued
Week 8 – Unit 3 -- Race

Week 9 – Unit 3 continued
Week 10 – Unit 4 -- Violence and War
Week 11 – Unit 4 continued
Week 12 – Unit 5 -- Living in a Globalized World
Week 13 – Unit 5 continued
Week 14 – Concluding lectures, discussion on exam pattern, etc.

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Individual
Society
Caste
Class
Gender
Race
Violence
Globalisation

Committee members

Madhumita Chakraborty, Zakir Husain Delhi College Evening – Coordinator
Rudrashish Chakraborty, Kirorimal College
Payal Nagpal, Janki Devi Memorial College
Sanam Khanna, Kamla Nehru College

PAPER G15: WESTERN PERFORMANCE THEORIES AND PRACTICES

Course Objectives

This course combines modern Western theatrical concepts along with the praxis of performance. Itwill familiarise students with the seminal Western theories of performance in the twentieth century and their visualisation on stage The coursewill focus on a historical understanding of the different types of theatrical spaces along with their bearing on performance. A practice based course, it will focus on techniques such as voice modulation and body movement A designated unit towards production will help students understand the different aspects involved in theatrical production

Unit 1
Introduction

- Introduction to western theories of performance; classical to contemporary Endorsement of existing structures to radicalising our world
- Historical overview of western theatre

Topics for Student Presentations:

a) Perspectives on theatre and performance
b) Historical development of theatrical forms
c) Popular traditions

Unit 2
Theatrical Forms and Practices

a) Performative spaces: eg., proscenium 'in the round' amphitheatre open-air and thrust stage; their impact on meanings of performance
b) Performance components: voice modulation and body movement

Topics for Student Presentations:

a) On the different types of performative space in practice
b) Poetry reading elocution expressive gestures and choreographed movement

Unit 3
Theories of Drama

Theories and demonstrations of acting: Stanislavsky, Brecht,Boal

Topic for Student Presentations:

Acting short solo/ group performances followed by discussion and analysis with application of theoretical perspectives

Unit 4
Theatrical Production

a) Direction production stage props costume lighting backstage support
b) Recording/archiving performance/case study of production/performance/impact of media on performance processes

Topic for Student Presentations:

All aspects of production and performance: recording, archiving, interviewing performers, and data collection

Unit 5
Final practical assignment

a) A performance of minimum thirty minutes using any one form of drama studied in this course
b) Interview at least one theatre practitioner who has worked with western theatrical forms

Week-wise teaching plan

Week 1 – Introduction to GE course on Western Performance Theories and Practices
Week 2 – Unit 1 -- Introduction
Week 3 – Unit 1 continued
Week 4 – Unit2 --Popular Theatrical Forms and Practices
Week 5 – Unit 2 continued
Week 6 – Unit 2 continued
Week 7 – Unit 3 --Theories of Drama
Week 8 – Unit 3 continued
Week 9 – Unit 4 --Theatrical Production
Week 10 -- Unit 4 continued
Week 11 – Unit 5 -- Field work: Interviewing a theatre practitioner
Week 12 – Unit 5 continued -- Working towards a Performance
Week 13 – Unit 5 continued -- Working towards a Performance
Week 14 – Concluding lectures exam issues, etc.

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Performance
Performativity
Performance spaces
Stanislavsky
Brecht
Boal
Voice modulation and body movement
Direction
Production
Stage props
Costume
Lighting
Backstage support

Committee members

Payal Nagpal, Janki Devi Memorial College -- Coordinator
Sanjay Kumar, Hansraj College
Sanjib Kumar Baishya, Zakir Husain Delhi College Evening
Anas Tabraiz, Zakir Husain Delhi College Evening
Anuradha Marwah, Zakir Husain Delhi College

PAPER G16: LITERATURE AND THE CONTEMPORARY WORLD

Course Objectives

This course seeks to introduce students to various genres of contemporary literature through works that are familiar and have established themselves in the popular parlance These texts will be studied from various prisms – class, caste, gender, race, etc., and will equip students with an understanding of the linkages between literature history and society in our times

Course Content

Unit 1

Isabel Allende,*The House of the Spirits*(Everyman's Library, 2005)

Unit 2

Khaled Hossaini,*The Kite Runner*(Bloomsbury, 2013)

Unit 3

Wole Soyinka, *A Dance of the Forests*(Three Crowns, 1963)

Unit 4

Short stories

a) Julio Cortaza,'The Sky Wide Open',*The Oxford Book of Latin America*, ed. Roberto Gonzalez Echevarria (OUP, 1997).
b) Chimamanda Ngozi Adichie,'The American Embassy',*The Thing Around Your Neck*(Harper Collins, 2009)
c) TenzinTsundue,'Kora',*Kora: Stories and Poems*(New Delhi, 2002)

Poems

a) Nazim Hikmet,'Ninth Anniversary',*Poems of Nazim Hikmet*, trans. Randy Blasing and Mutlu Konuk (New York: Persea Books, 2002)
b) Maya Angelou,'On the Pulse of Morning',*The Complete Collected Poems of Maya Angelou* (Random House Publishing Group, 1994)
c) Yasmine Gooneratne,'Big Match 1983',*The Arnold Anthology of Post-Colonial Literatures in English*, ed. John Thieme (USA: Oxford University Press, 2000)

Week-wise Teaching Plan

Week 1: Introductory lectures on the interdisciplinary nature of literature its intersections with history and politics in the contemporary world
Week 2: Unit 1 – Allende,*The House of the Spirits* -- analysis of the context and text
Week 3: Unit 1 continued
Week 4: Unit 1 continued
Week 5:Unit 2 –Hossaini,*The Kite Runner* -- historical background and textual analysis
Week 6: Unit 2 continued
Week 7: Unit 2 continued
Week 8: Unit 3 – Soyinka, *A Dance of the Forests*
Week 9: Unit 3 continued
Week 10: Unit 3 continued
Week 11: Unit 4 -- Introduction to the short story: Cortaza, 'The Sky Wide Open';Adichie, 'The American Embassy'
Week 12: Unit 4 continued – Tsundue, 'Kora'; introduction to poetry; Hikmet, 'Ninth Anniversary'
Week 13: Unit 4 continued –Angelou, 'On the Pulse of Morning'; Gooneratne 'Big Match 1983'
Week 14: Concluding lectures on genre, the category of 'world literature', globalization, and conflict – gender,class, race, and nationhood

Facilitating the Achievement of Course Learning Outcomes

Sl No	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
2	Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
3	Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Art
Genre
History
Politics
Globalisation
Race
Class
Gender

Committee members

Mudita Mohile, Gargi College -- Coordinator
Brati Biswas, Dyal Singh Evening College
Madhumita Chakraborty, Zakir Husain Delhi College Evening
Karuna Rajeev, Lady Shri Ram College for Women

AECC

Course Objectives

Effective communication is an essential skill for success in any sphere of life from leadership responsibilities teamwork interviews presentations and inter-personal relations. This is a skill that needs to be taught in a systematic manner so that students imbibe the fundamentals of both creating and receiving communication. All speech and writing intends to persuade an audience of the author's point of view whether that audience is a single person or a large group. The art of persuasive speaking and writing depends crucially on clarity of thought regarding one's own intentions. In addition one must assume all audiences to be skeptical and therefore difficult to persuade. In order to succeed at persuasion we need to use multiple persuasive strategies.

The ability to think critically is crucial for a good communicator and involves several steps: first to be aware of where our ideas come from and to be aware of the power structure within which these ideas exist second to understand our audience and readers their ways of thinking their perceptions so that we can attempt to alter those perceptions and persuade them to accept ours third to intelligently determine what tools we should use to appeal to our audience – to their logic their emotions their ethics and morality and finally to convey what we want to do once we have persuaded them that is to recognize our proposed course of action. All of these aspects are present in rudimentary form in our minds every time we speak or write whether we are persuading our examiner to give us more marks or convincing our parents to let us go on an outstation trip. We often use persuasive strategies instinctively but unconsciously. However if we study every stage of this process systematically then we will be much more effective at communicating successfully in interviews public speaking letter writing report writing presentations and inter-personal relations.

Learning Outcomes

- Students should master the art of persuasive speech and writing.
- Students should master the art of listening reading and analyzing. Students will spend the bulk of their time in class reading other people's writing so a good student is also a good reader one who interprets the text carefully and one who clearly recognizes the author's intentions and strategies.
- Students should become skilled at critical thinking whether while writing or while analysing.
- They will be introduced to principles established in universities the world over principles of academic reading and writing. These principles are based on tried and tested formulae evolved by the ancient Greeks chiefly discussed in Aristotle's writings on rhetoric.
- The courseis divided into five sections. The first section defines the text the next two sections relate to authors their intentions and strategies the fourth section examines the ways in which the text is received by audiences and readers and the fifth and final section
- Students are trained to look at the ways in which to structure a written argument in an academic assignment. The first section contains four samples of writing by different authors and each subsequent section includes three samples of writing. Students willanalyse each sample based primarily on the aspects we are discussing in that section.

However we need to be aware of the fact that the five sections are not watertight categories but fluid indications with many overlaps. Each text in any section can be analysed using a variety of strategies ranging over text context author and audience.

AECC

The following is an outline of the sections and their readings:

1. **Understanding the Text**

   General Your Tank
   Why I Want a Wife
   Fire and Ice
   Chinese Folk Tale

2. **Contextualisation and Perspectivism**

   A Lesson in Drawing
   My Young Men Shall Not Work
   The Paper Bag Princess

3. **Reception**

   'Much Madness'
   Disability Conversation Letter
   The Eyes Have It

4. **Evaluation and Synthesis**

   Ain't I A Woman?
   Imagine
   Girls

5. **Analysis**

   Bosom Friend
   An Enabling Garment
   Story of an Hour

Teaching Plan
AECC

Week 1 – Introduction to AECC: Communication Critical Thinking Writing Speaking
Week 2 – Introduction of Concepts (contd)
Week 3 – **Unit 1 – Understanding the Text:**
General Your Tank
Why I Want a Wife
Fire and Ice
Chinese Folk Tale
Week 4 – Understanding the Text (contd)
Week 5 – **Unit 2** -- **Contextualisation and Perspectivism**
A Lesson in Drawing
My Young Men Shall Not Work
The Paper Bag Princess
Week 6 – **Contextualisation and Perspectivism** (contd)
Week 7 – **Unit 3: Reception**
'Much Madness'
Disability Conversation Letter
The Eyes Have It
Week 8**– Reception** (contd)
Week 9 – **Unit 4: Evaluation and Synthesis:**
Ain't I A Woman?
Imagine
Girls

Week 10 – Evaluation and Synthesis (contd)
Week 11–**Unit 5: Analysis**
Bosom Friend
An Enabling Garment
Story of an Hour
Week 12 – Analysis (contd)
Week 12 – Clarifying concepts through group discussions
Week 13 – Expressing concepts through practicing writing
Week 14 – Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts	Interactive discussions with students to aid critical thinking through reading and listening	Reading material together in small groups listening to material from different media working in peer groups to discuss material
2.	Expressing concepts through speech	How to think critically and express with clarity	Group discussions public speaking dialogue interview
3.	Demonstrating conceptual and textual understanding through writing assignments tests and exams	Discussing exam questions and answering techniques	Class tests assignments

Keywords

Critical reading
Comprehension
Summary
Paraphrase
Translation
Context
Argumentation
Perspective
Reception

Audience
Evaluation
Synthesis
Communication theory
Verbal communication
Non-verbal communication
Personal communication
Social communication
Barriers to communication
Intra-personal communication
Inter-personal communication
Group discussion
Miscommunication
Public speech
Literary knowledge
Writing skills
Documentation
Report writing
Note taking
Letter writing

Sub-committee

Vinita Chandra Ramjas College (Coordinator)
Roopa Dhawan Ramjas College

AECC Syllabus with Readings

1. Introduction
Theory of Communication Types and modes of Communication (Introductions to all Five Sections)

2. Language of Communication:
Verbal and Non-verbal (Ain't I a Woman) (Spoken and Written)
Personal communication (Why I Want a Wife)
Social communication (Imagine)
Business Communication (Women Smohalla)
Barriers and Strategies (An Enabling Garment)
Intra-personal Communication (Women)
Inter-personal Communication (Why I Want a Wife)
Group communication (Fire and Ice)

3. Speaking Skills:
Monologue (The Paper Bag Princess)
Dialogue (Why I Want a Wife The Story of an Hour)
Group Discussion Fire and Ice
Effective Communication Imagine
Mis-Communication (A Lesson in Drawing)
Public Speech (Girls)

4. Reading and Understanding
Close Reading (The Eyes Have It)
Comprehension (Ain't I a Woman?)
Summary (Disability Conversation)
Paraphrasing (Much Madness)
Analysis (Enabling Garment)
Interpretation (Ain't I a Woman)
Translation (Girls) (from Indian languages to English and vice-versa)
Literary/Knowledge Texts (Why I Want a Wife Fire and Ice Story of an Hour)

5. Writing Skills
Documenting (Much Madness)
Report Writing (Smohalla)
Making notes (A Lesson in Drawing)
Letter writing (Chinese Folk Tale Disability Conversation)

List of readings plus syllabus applications

1. **Understanding the Text**

   General Your Tank
   Why I Want a Wife Interpersonal dialogue
   Fire and Ice Group discussion
   Chinese Folk Tale Letter Writing Intrapersonal dialogue

2. **Contextualisation and Perspectivism (Definition)**

   A Lesson in Drawing Miscommunication Notes Analysis
   My Young Men Shall Not Work Report
   The Paper Bag Princess Monologue

3. **Reception (Audience – Appeals)**

   'Much Madness' Paraphrase Documentation
   Disability Conversation Letter Summary Informal Letter
   The Eyes Have It Close Reading

4. **Evaluation and Synthesis**

    Ain't I A Woman? Verbal and non-verbal communication Paraphrase Comprehension
    Imagine Public letter (semi-formal)
    Girls Public speech Translation

5. **Analysis**

    Bosom Friend Report Analysis Argumentation
    An Enabling Garment Communication Barriers and Strategies Analysis
    Story of an Hour Dialogue

AECC DETAILED COURSE MATERIAL

SECTION 1 - UNDERSTANDING THE TEXT

What is a text? A text is anything we can read. We assume that we can only read words on paper or screen. However we 'read' everything around us as text every moment of our lives: we read people as texts from the clothes they wear the way they speak to their expressions and actions we read spaces as text as to whether they are hostile inclusive safe welcoming or intimidating and we certainly read events as texts when we consider evidence of what happened different perspectives of the event the situation or the outcome. At a much simpler level we read songs movies advertisements billboards pictures. Whether we think about any of these things critically or not our brain responds to everything around us by 'reading' it at some level analysing and finally arriving at a value judgment. Because this is the process we are constantly undertaking it becomes very important to undertake it consciously and with critical awareness.

No matter what kinds of texts we are trying to read the arguments are essentially of three kinds. That is there are only three ways in which a text presents itself. One it may be defining something by answering the question 'What is it?' For example an author may be defining beauty. What is beauty? Is it a rosy complexion and big eyes? Or is it kindheartedness and courage? Two the text might be evaluating something or answering the question 'Is it good or bad?' or 'What is its value?' For instance is *Dangal* a good film about women's empowerment? Or is it a problematic film that emphasizes women's lack of freedom to choose? Three a text can be presenting a proposal or answering the question 'What should be done about it?'. By way of illustration can we solve border disputes by war or by diplomacy? So a text will try to be persuasive through definition evaluation or proposal.

In this course you are looking exclusively at those texts that use the written word. While you read them pay attention to what genre of text is before you. You will be able to identify different genres: a short story an essay a poem a song. How are they different from one another?

Readings for Section 1

General Your Tank is A Powerful Vehicle

Bertolt Brecht

Bertolt Brecht (1898-1956) a German poet playwright and theatre director was an influential literary figure of the twentieth century. He started writing newspaper articles including theatre reviews at the age of eighteen. When he was nineteen he won for his first three plays the Kleist prize Germany's most prestigious literary award at the time. He is associated with the Neue Sachlichkeit (New Objectivity) movement in German art with the collaborative approach to artistic production and with the experimental genre 'epic theatre'. He has written hundreds of poems and many plays such as *Mother Courage and Her Children* (1938) and *The Good Person of Szechwan* (1939).

A committed Marxist all his life he expressed his opposition to the National Socialist and Fascist movements of Europe through his creative and theoretical writings. As a result he had to leave Germany in 1933 fearing persecution by Hitler's regime and ultimately went to America after Hitler proceeded to invade most of Europe. Even in America his extreme communist political views resulted in his being targeted by the government.

His writings advocate independent thinking and anti-establishment political action. 'General Your Tank' was probably written between the two world wars. Here he underscores the power of critical thought as the ultimate weapon against war and oppression.

****

General your tank is a powerful vehicle.
It smashes down forests and crushes a hundred men.
But it has one defect:
It needs a driver.

General your bomber is powerful.
But it has one defect:

It needs a mechanic.

General man is very useful.
He can fly and he can kill.
But he has one defect:
He can think.

Questions:

1. The text suggests that the tank and the bomber are not perfect. Usually one would assume drivers and mechanics to be helpful to machines. The poet suggests that this may not be the case. Why does he think so?
2. In the third stanza the human being flies and kills for the general. As such the human is powerful. What is the single word that indicates that power?
3. Why does thinking make a human being defective? For whom is he thus defective? For himself or for the general?
4. Why is a thinking human inconvenient for armies and wars?Why might wars require humans who do not or cannot think?
5. Does Brecht highlight the power of all kinds of thinking or only some kinds? Consider concepts such as debating criticizing challenging questioning opposing rebelling etc.
6. What is the purpose and effectiveness of repetition in this poem? How does the genre of poetry help put forward the poet's message? Note similar uses of repetition in other texts in this course: 'Why I Want a Wife' 'My Young Men Shall Not Work' 'Ain't I a Woman?' and 'Imagine.'

Application

Write a speech for college students on the power of critical thinking and its benefits to society. Use repetition in the speech to strengthen the argument.

Why I Want a Wife

Judy Brady

Judy Brady (1937-2017) was an American feminist a political and environmental activist and a freelance writer. She was part of what was then known as the Women's Liberation movement. Women were fighting for multiple social and political rights and had won the right to vote and finally the right to an abortion. However the women's movement was an ongoing battle and Brady like other activists fought it on several fronts. She became a prominent figure in the West Coast Women's Liberation movement.

Her classic essay ‘Why I Want a Wife’ was first published in the first issue of *Ms.* magazine in 1972 and reprinted as ‘Why I [Still] Want a Wife’ in *Ms.* in 1990. For the first publication she used her married name of Syfers but subsequently used her maiden name Brady as an early declaration of independence from marital convention. She first read her essay in San Francisco to a crowd celebrating the 50th anniversary of the 19th amendment that gave American women the right to vote.

****

I belong to that classification of people known as wives. I am A Wife. And not altogether incidentally I am a mother.

Not too long ago a male friend of mine appeared on the scene fresh from a recent divorce. He had one child who is of course with his ex-wife. He is looking for another wife. As I thought about him while I was ironing one evening it suddenly occurred to me that I too would like to have a wife. Why do I want a wife?

I would like to go back to school so that I can become economically independent support myself and if need be support those dependent upon me. I want a wife who will work and send me to school. And while I am going to school I want a wife to take care of my children. I want a wife to keep track of the children's doctor and dentist appointments. And to keep track of mine too. I want a wife to make sure my children eat properly and are kept clean. I want a wife who will wash the children's clothes and keep them mended. I want a wife who is a good nurturant attendant to my children who arranges for their schooling makes sure that they have an adequate social life with their peers takes them to the park the zoo etc. I want a wife who takes care of the children when they are sick a wife who arranges to be around when the children need special care because of course I cannot miss classes at school. My wife must arrange to lose time at work and not lose the job. It may mean a small cut in my wife's income from time to time but I guess I can tolerate that. Needless to say my wife will arrange and pay for the care of the children while my wife is working.

I want a wife who will take care of my physical needs. I want a wife who will keep my house clean. A wife who will pick up after my children a wife who will pick up after me. I want a wife who will keep my clothes clean ironed mended replaced when need be and who will see to it that my personal things are kept in their proper place so that I can find what I need the minute I need it. I want a wife who cooks the meals a wife who is a good cook. I want a wife who will planthe menus do the necessary grocery shopping prepare the meals serve them pleasantly and then do the cleaning up while I do my studying. I want a wife who will care for me when I am sick and sympathize with my pain and loss of time from school. I want a wife to go along when our family takes a vacation so that someone can continue to care for me and my children when I need a rest and change of scene.

I want a wife who will not bother me with rambling complaints about a wife's duties. But I want a wife who will listen to me when I feel the need to explain a rather difficult point I have come across in my course studies. And I want a wife who will type my papers for me when I have written them.

I want a wife who will take care of the details of my social life. When my wife and I are invited out by my friends I want a wife who will take care of the baby-sitting arrangements. When I meet people at school that I like and want to entertain I want a wife who will have the house clean will prepare a special meal serve it to me and my friends and not interrupt when I talk about things that interest me and my friends. I want a wife who will have arranged that the children are fed and ready for bed before my guests arrive so that the children do not bother us. I want a wife who takes care of the needs of my guests so that they feel comfortable who makes sure that they have an ashtray that they are passed the hors d'oeuvres that they are offered a second helping of the food that their wine glasses are replenished when necessary that their coffee is served to them as they like it. And I want a wife who knows that sometimes I need a night out by myself.

I want a wife who is sensitive to my sexual needs a wife who makes love passionately and eagerly when I feel like it a wife who makes sure that I am satisfied. And of course I want a wife who will not demand sexual attentionwhen I am not in the mood for it. I want a wife who assumes the complete responsibility for birth control because I do not want more children. I want a wife who will remain sexually faithful to me so that I do not have to clutter up my intellectual life with jealousies. And I want a wife who understands that my sexual needs may entail more than strict adherence to monogamy. I must after all be able to relate to people as fully as possible.

If by chance I find another person more suitable as a wife than the wife I already have I want the liberty to replace my present wife with another one. Naturally I will expect a fresh new life my wife will take the children and be solely responsible for them so that I am left free.

When I am through with school and have a job I want my wife to quit working and remain at home so that my wife can more fully and completely take care of a wife's duties. My God who wouldn't want a wife?

Questions

1. By describing a typical wife what is Brady actually saying about typical wives? What is the central argument of the text?
2. While discussing wives what kinds of evidence does the author present in support of her point? How is a wife defined? What are her duties?
3. What kind of reader does the text seek to persuade? Why do you think Brady focuses on this population of readers?

4. The title states that Brady would like a wife for herself. The phrase ‘I want a wife’ is repeated multiple times in the text. Does this mean that Brady approves of typical wives? Does she really want a wife? Or are the title and the essay ironical? If so how so?
5. How do you think women reading this article would respond? Would different kinds of women respond in different ways? Likewise how do you think men would respond?
6. What kind of person is the speaker? Is she a typical wife herself? In that case why would she too want a wife?
7. What would the male equivalent of this wife be like? How does our society define an ideal husband?

Application

Write aninterpersonal dialogue between two friends(a wife and a single woman) in which they are debating the disadvantages and advantages of being either married or single.

Fire and Ice

Robert Frost

Robert Frost (1874-1963) was an American poet known for the simplicity of his style. Yet his matter-of-fact vocabulary masked heavily ironic and symbolic ideas. He was frequently awarded during his lifetime receiving four Pulitzer Prizes for poetry.

A popular anecdote about this poem relates that the then famed scientist Harlow Shapley met Frost during a social gathering a couple of years before this poem was published. According to Shapley Frost asked him how the world would end. Shapley replied that it would either be burnt by the sun or a permanent ice age would descend upon it.

However one of Frost's biographers suggests that ‘Fire and Ice’ was inspired by a passage in Canto 32 of Dante's *Inferno* where while in hell the worst sinners are submerged in ice. The poem was first published in 1920 in *Harper’s Magazine*. Frost moves beyond the literal using the popular scientificbelief only as a springboard to discuss human emotions like desire and hatred. The poem contains the familiar Frostian combination of opposites—moderation of language and tone contrasted with serious philosophical themes.

****

Some say the world will end in fire
Some say in ice.□
From what I've tasted of desire
I hold with those who favor fire.□

But if it had to perish twice□
I think I know enough of hate
To say that for destruction ice□
Is also great□
And would suffice.

Questions

1. While considering the two ways in which the world will end the poet begins by choosing the side of fire (in the first stanza). Why does he make that choice? What is the symbolic connection between fire and desire? Why do we associate passion with the colour red?
2. The entire second stanza is about hatred. Does this stanza therefore overturn his earlier choice of desire for destruction? Does he now think it is more likely that hatred will end the world? If so why so?
3. The opening of this poem suggests that a scientific question is being debated the contest between two end-of-the-world scenarios. How does the text manage to remove us from the scientific and transport us to the philosophical?
4. What do you think is more destructive for humankind? Desire or hatred? Can you think of examples for both in our modern social climate? Could elements like power greed corruption materialism war envy contribute to the destruction of the world?

Application

Consider a group discussion (amongst four people) about the various social factors that might contribute to the destruction of humankind. This would involve four different points of view on the subject. Are we as a species as vulnerable to extinction as animals and plant species? In what ways could our destruction be self-inflicted?

Women

[Anonymous]

Like most folk tales this Chinese tale is undated and anonymous. Chinese folklore is influenced by the country’s religions such as Taoism Confucianism and Buddhism. Emerging from a civilization that is about 4000 years old these tales span multiple styles and subjects ranging from stories with morals those about philosophical subjects cautionary tales ghost stories satirical tales those involving the gods and those focusing on ordinary humans. Multiple levels of character commentaries are represented including values like moderation loyalty justice and wisdom.A variety of tones are employed such as gentle and meditative aggressive and down-to-earth and ironical.

The tale narrated here called 'Women' perhaps belongs to that last category. It speaks of a husband's desire to control his wife and the innovative way in which he seeks to 'imprison' her. The story ironically relates the way in which the tables are turned upon him.

****

After he was married Chang the Third no longer wanted to go to work. He sat at home the whole day and played with his wife. He gazed endlessly at her beautiful face and the longer he looked the less he wanted to go out. Finally he gave up his job and remained night and day with his wife. He went on this way for six months and then for a year but even the largest fortune is soon exhausted if one does nothing and Chang had merely lived on his earnings. In two years all his wife's jewels the chairs the tables the linen the clothes in fact everything they had was pawned or sold and they were left without a penny.

His wife was really unusually beautiful but she thought to herself 'Since his marriage my husband has never left the house. Day and night he sits around nothing but eat. In a short while we shall no longer have the wherewithal to live.' So she upbraided him saying 'You really can't stay at home all day. All men must go to work.' But Chang saw her beauty and he thought anxiously 'If I went out another man could come and make love to her.' And instead of listening to her words he remained at home preferring to eat the most miserable food.

But eventually their poverty became unbearable. They could no longer live if he did not work. Finally one morning he said good-bye to his wife and decided to go to a village. On his way he met a fine-looking man of about fifty years who said to him 'Which is the way to such and such a village?' Chang answered 'I am going there myself so we can go together.' During their walk Chang told the stranger his story. 'I am so unhappy at leaving my wife' he said. 'But I must look for work to enable us to live.'

The stranger replied 'The simplest thing is to bottle up your wife. I will give you the bottle and every day when you leave you will only need to look at your wife and blow into the bottle and she will vanish inside at once. As you can always take it with you you will never need to lose your wife. I must now take another road so farewell.' Then he handed Chang a large three-inch bottle from h is bag and disappeared. Chang dropped the bottle into his bag noting what the man had said and set off gaily for the village. The next day he tried the gift. As his wife was combing her hair before the mirror he secretly blew into the bottle. The woman saw in the mirror the reflection of her husband blowing into a bottle but hen she lost consciousness and woke up to find herself inside the bottle. Chang put the bottle in his pocket and went off to his work in the village. He was quite contented for no other man could flirt with his wife. In the evening he tipped the bottle and his beautiful wife stood before him as before.

One day however he was forced to leave his wife at home to do the washing. He begged her not to leave the house when the washing was finished and then set off to the village forgetting to take the bottle with him.

After he husband's departure the wife went down to the river to wash the clothes. While she was rinsing a shirt she suddenly felt a long hard thing between her fingers. She took it out and looked at it carefully. 'It's a bottle' she said to herself. 'Every morning my husband blows into it and I vanish inside. Why has he forgotten it today?' While she was pondering over the matter a handsome young man passed by on the other bank. She looked up at him and without thinking what she was doing blew into the bottle whereupon the young man disappeared. When she had finished the washing she replaced the bottle in her husband's clothes.

When the man arrived home he immediately asked for the bottle he had left behind and his wife handed it to him without a work. The next day when he went out he blew into the bottle as usual and his wife disappeared and again he flattered himself that she was safe from the caresses of other men.

That evening on his return he tipped the bottle but this time two people appeared his wife and a handsome young man. He was very much surprised and said to himself. 'How strange! I thought my wife was quite safe shut up in a bottle but now she has got a man with her! How odd it is! And how impossible it is to keep a beautiful wife to oneself.'

Questions

1. Describe the relationship between Chang and his wife. How does it change in the course of the story? In what ways does Chang try to control his wife?
2. What type of marriage does the bottle symbolize? What does the mirror symbolize? What role do symbols play in the text of folk tales?
3. What seems to be the point of this tale? (Consider that it was the husband himself who bottled up his wife with a potential lover.) Folk tales are supposed to impart wisdom to the community. Why would the wisdom or lesson of this story be an important one?
4. Do you think the title works? Why or why not? Would an equally good title be 'Men'? Could you argue that the story exposes male nature? How could this text be rewritten for the present day?

Applications

1. As president of the students' union writea formal letter to your principal drawing her attention to the various forms of sexual harassment in your college.
2. Write an intra-personal monologue in which the woman speaks to herself about this entire incident. Note: she will retell the story from her point of view.

SECTION 2 – CONTEXTUALISATION AND PERSPECTIVISM

When we read a text it is crucial to first place it in its historical social political and economic context. A story or poem written in 1917 will certainly be different to one written in 1947 or in 2017. (How do you think it would be different?) A song or a play written in India is likely to be different from one written in Iceland. (Where would those differences come from?) A text emerging from the Hindu tradition would sound/read differently from one formed within the Christian tradition. Therefore before we start reading a text we need to be aware of the cultural material context in terms of the time period in which it was written the geographical location the community the economic and social background of the writer the political climate prevailing at the time and so on.

The context determines the perspective of the author. We do not need to agree with the perspective but we need to understand it before we critique it or even accept it. The perspective of an author in India in the 1930s in the midst of the freedom struggle is bound to differ from that of an author in Europe at the same time since the 1930s in Europe was the period of the Great Depression between the two world wars. The perspective of a woman who walks in the streets of Delhi after dark will certainly not be the same as that of a man. Every author writes/creates from their own perspective and we will read the text better if we identify this perspective.

Readings for Section 2

A Lesson in Drawing

Nizar Qabbani

Nizar Tawfiq Qabbani (1923-1998) was a celebrated Syrian poet and publisher. He started writing poetry at the age of sixteen and self-published his first poetic collection. Initially his poetic themes were mainly about romantic and erotic love and themes deeply sympathetic to women. He was affected when he was fifteen by the death of his sister who killed herself because she was being forced into marriage. This incident triggered in him an interest in the problems of Arab women. In his later career his work focused on issues of Arab identity and had political themes highlighting the social and political turmoil of Syria and other Arab countries.

In ‘A Lesson in Drawing’ Qabbani draws attention to the several levels of loss suffered by those living in extended war-torn regions and their dreams of a pre-war homeland.

****

My son places his paint box in front of me
and asks me to draw a bird for him.
Into the color gray I dip the brush
and draw a square with locks and bars.
Astonishment fills his eyes:
‘… But this is a prison Father
Don’t you know how to draw a bird?’
And I tell him: ‘Son forgive me.
I’ve forgotten the shapes of birds.’

My son puts the drawing book in front of me
and asks me to draw a wheatstalk.
I hold the pen
and draw a gun.
My son mocks my ignorance
demanding
‘Don’t you know Father the difference between a
wheatstalk and a gun?’
I tell him ‘Son
once I used to know the shapes of wheatstalks
the shape of the loaf
the shape of the rose
But in this hardened time
the trees of the forest have joined
the militia men
and the rose wears dull fatigues
In this time of armed wheatstalks
armed birds
armed culture
and armed religion
you can’t buy a loaf
without finding a gun inside
you can’t pluck a rose in the field

without its raising its thorns in your face
you can’t buy a book
that doesn’t explode between your fingers.’

My son sits at the edge of my bed
and asks me to recite a poem
A tear falls from my eyes onto the pillow.
My son licks it up astonished saying:
‘But this is a tear father not a poem!’
And I tell him:
‘When you grow up my son
and read the diwan of Arabic poetry
you’ll discover that the word and the tear are twins
and the Arabic poem
is no more than a tear wept by writing fingers.’

My son lays down his pens his crayon box in
front of me
and asks me to draw a homeland for him.
The brush trembles in my hands
and I sink weeping.

Questions

1. How does the poem present two contrasting perspectives? Why are those perspectives so different from one another? Is it only because one is a child’s point of view and the other an adult’s?
2. How would an understanding of Syrian culture and politics enable us to better appreciate the ideas in the poem?
3. The first two stanzas of the poem focus on the natural agricultural economic and cultural changes in the landscape of Syria because of the war. What is the effect on the reader of these multiple ways of examining a problem?
4. The fourth stanza focuses on the ways in which Arabic poetry is able to express grief and loss. Can Arabic art as Qabbani suggests arrive at the truth about the Arab experience in the Middle East?
5. How does the poet use imagery rather than logical argument to present his perspective? Can you identify some of those images?
6. How do wars alter the life experiences of ordinary people living in those regions? Think closer to home of similar conflicted regions like Kashmir and the Indian northeast.

Applications

1. ‘A Lesson in Drawing’ displays a series of miscommunications between son and father. Make notes on the different ways this happens.
2. Write an essay on how and why miscommunication takes place between people paying attention to ideas like conflicting assumptions and contexts.

My Young Men Shall Not Work

Chief Smohalla

Smohalla (1815-1895) was a Native American warrior medicine man and spiritual leader best known for introducing a revitalized Washani religion amongst his people the Wanapums of America's Pacific Northwest. Smohalla is closely associated with the Dreamer religion as the new Washani faith came to be called. It emerged in part as a reaction to the intrusions of white settlers the U. S. Army and the subsequent Indian policies of the U. S. government. The Dreamer faith which spread rapidly in the mid- and late-nineteenth century called for a return to Native American traditions and lifestyles and a rejection of white cultural influences. Because Smohalla's religious doctrines were so deeply ingrained in the traditional religious beliefs of the Wanapum people they continued to be a part of the spiritual life of the Native American cultures of the Pacific Northwest well into the twentieth century.

The Nez Perce are a tribe of American Indians formerly occupying much of the Pacific Northwest whose reservation is in Idaho. Because Native Americans resisted giving up their homes and nomadic way of life to become farmers white people have often called them lazy stubborn and impractical. But to Indians for whom land and hunting were sacred anything that threatened any one of these threatened their whole system of beliefs and values—in short their very life.

****

My young men shall never work. Men who work cannot dream and wisdom comes in dreams.

You ask me to plow the ground. Shall I take a knife and tear my mother’s breast? Then when I die she will not take me to her bosom to rest.

You ask me to dig for stone. Shall I dig under her skin for bones? Then when I die I cannot enter her body to be born again.

You ask me to cut grass and make hay and sell it and be rich like white men. But how dare I cut off my mother’s hair?

It is a bad law and my people cannot obey it. I want my people to stay with me here. All the dead men will come to life again. We must wait here in the house of our fathers and be ready to meet them in the body of our mother.

Questions

1. In what ways does Smohalla describe the earth as the body of the mother? Do you think this metaphor is appropriately used? Do many cultures call their land 'Mother Earth'?
2. How does the perspective of viewing the earth literally as the body of the mother change the way we think about farming mining construction industrialization? How does this perspective affect the way we think about work? Would hunting fishing and gathering fruits be considered work?
3. What does the context of the Nez Perce and the Native Americans tell us about tribal values? Do we see similar tribal values in India where the earth and water bodies are sacred and are protected from mining and industrial use?
4. Are the Nez Perce objecting to all work? What do they value more than work? How common is it for a culture to place the highest value on something other than work?
5. Smohalla followed the Dreamer religion. In what context would dreaming and imagining become more important than work? Can we review our own context of the work ethic from the perspective of the Dreamer faith?

Application

Write a report on homework and punishment in school policy.

The Paper Bag Princess

Robert Munsch

Robert Munsch (b. 1949) is an American writer of children's books. He grew up in a family of nine children and has written more than 25 books for children including *The Paper Bag Princess* (1980) and *Stephanie's Ponytail* (1996). He studied to be a Jesuit priest before deciding to work with children instead. He taught in a variety of nursery schools and daycare centers while he earned a master's degree in Early Childhood Education.

On his website Robert Munsch says '*The Paper Bag Princess* was first told at the Bay Area Child Care Center in Oregon where I had a job in 1973 and 1974. I had been telling lots and lots of dragon stories. They were all fairly regular dragon stories where the prince saves the princess from the dragon. One day my wife who also worked at the daycare centre said 'How come you always have the prince save the princess? Why can't the princess save the prince?''

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When Elizabeth was a beautiful princess she lived in a castle and had expensive princess clothes. She was going to marry a prince named Ronald. Unfortunately a dragon smashed her castle burned all her clothes with his fiery breath and carried off Prince Ronald.

Elizabeth decided to chase the dragon and get Ronald back. She looked all over for something to wear but the only thing she could find that was not burnt was a paper bag. So she put on the paper bag and followed the dragon. He was easy to follow because he left a trail of burnt forests and houses' teeth.

Finally Elizabeth came to a cave with a large door that had a huge knocker on it. She took hold of the knocker and banged on the door. The dragon stuck his nose out the door and said 'Well a princess! I love to eat princesses but I have already eaten a whole castle today. I am a very busy dragon. Come back tomorrow.' He slammed the door so fast that Elizabeth almost got her nose caught.

'Is it true' said Elizabeth 'That you can burn up ten forests with your fiery breath?'

'Oh yes' said the dragon and he took a huge deep breath and breathed out so much fire that he burnt up fifty forests.

'Fantastic' said Elizabeth and the dragon took another huge breath and breathed out so much fire that he burnt up one hundred forests. 'Magnificent' said Elizabeth and the dragon took another huge breath but this time nothing came out. The dragon didn't even have enough fire left to cook a meatball.

Elizabeth said 'Dragon is it true that you can fly around the world in just ten seconds?'

'Why yes' said the dragon and jumped up and flew all the way around the world in just ten seconds. He was very tired when he got back but Elizabeth shouted 'Fantastic do it again!'

So the dragon jumped up and flew around the whole world in just twenty seconds. When he got back he was too tired to talk and he lay down and went right to sleep.

Elizabeth whispered very softly ‘Hey dragon.’ The dragon didn't move at all. She lifted up the dragon's ear and put her head right inside. She shouted as loud as she could ‘Hey dragon!’ the dragon was so tired he didn't even move.

Elizabeth walked right over the dragon and opened the door to the cave. There was Prince Ronald. He looked at her and said ‘Boy are you a mess! You smell like ashes your hair is all tangled and you are wearing a dirty old paper bag. Come back when you're dressed like a real princess.

‘Ronald’ said Elizabeth ‘your clothes are really pretty and your hair is all neat. You look like a real prince but you are a bum.’ They didn't get married after all.

[Editor’s note: In the book (illustrated by Michael Martchenko) Elizabeth is shown at the end wearing a paper bag and dancing joyously into the sunset.]

Questions

1. This is a fairy tale written from a different perspective. What is that perspective? What is the context in which Munsch writes this tale?
2. Would we consider Princess Elizabeth an ‘unconventional’ princess? What are the reader’s expectations at the beginning of the fairy tale about the behavior and actions of Elizabeth once Ronald is taken away by the dragon? How do we expect Ronald to act? What is the significance of the absence of Ronald throughout the story? What are the implications of his being neither surprised nor grateful at being rescued by a girl?
3. Clothes play a crucial role in this fairy tale. Can we compare and contrast the role of clothes in this story with that of Cinderella?
4. Can we compare and contrast the role of beauty in this story and that of Snow White and the Seven Dwarfs or in The Frog Prince?
5. Analyze the context in which this story is written where Elizabeth immediately decides to chase the dragon and bring Ronald back and uses her resources of intelligence and wit to do so. Is the fairy tale set in a patriarchal context? In this context how would you analyze the ending of the story? Is it a disappointing ending since all fairy tales end with the prince and the princess being married and living happily ever after? Why does the fairy tale not begin with the phrase ‘Once upon a time…’?
6. Does the perspective of fairy tales influence children of impressionable age and do they eventually grow out of the ideas established about gender roles in these stories? In the context of women being educated having careers and being more independent should the narrative start changing?

Application

> Write a monologue spoken by the Dragon when he wakes up to find he has been outwitted and Ronald has escaped.

SECTION 3 – RECEPTION

We have seen in previous sections that understanding the author's context and his intentions facilitates our engagement with the text. In this section we will focus on the audience of a text meaning us or the reader. The author is not the only one with beliefs and biases. When we read a story or an article we too react to that story through the prism of our own beliefs and biases. We will only appreciate the text if the author has managed to appeal to our beliefs and to address our concerns.

There are three ways in which the author can appeal to the reader. The first is by using the *ethos* appeal. Through this method the author tries to present himself or herself as an attractive believable personality. The author must try to seem knowledgeable and trustworthy so that the audience is willing to believe the argument. The second is by employing the *logos* appeal. Through this strategy the author appeals to the audience's logic their reasonableness and their common sense. If this method works the audience will see the argument as rational and therefore believable. The third method called *pathos* appeals to the audience's emotions and values such as positive or negative feelings of sympathy solidarity outrage fear love shame or hatred. If the audience can be made to feel appropriate feelings for the author's arguments then they will more readily be persuaded.

Keep in mind: all persuasive texts are 'manipulative' in nature. This means that the author is trying to change your mind about something to encourage you to accept a different point of view. If you accept someone's opinion without critically applying your mind you risk being manipulated. But if you accept the author's arguments with knowledge and clarity you are not being manipulated but persuaded.

So when you read the texts in this section pay attention to how you as an audience or reader are being persuaded by the writer through the use of multiple strategies of argument. As readers you should be acutely aware of the author's intentions. Become a reader with critical awareness one who is not blindly brainwashed into believing anything a writer says. Become a reader who can be persuaded only after clear-headedly analysing the arguments examples and reasons provided by the author.

Readings for Section 3

‘Much Madness’

Emily Dickinson

Emily Dickinson (1830-1886) is considered one of the most original 19th century American poets. She lived in the orthodox environment of Amherst Massachusetts in an equally puritanical family. She is noted for her unconventional use of language and punctuation (such as her use of dashes and random capitalization). Her subjects are highly personal and individualistic and her poems usually challenge the ultra-religious beliefs of her society.

For various emotional and medical reasons Dickinson lived most of her life in the seclusion of her home. She seldom left her house and was often labeled abnormal anti-social and introverted. ‘Much Madness’ was probably written around 1862 though it was published along with all her poetry posthumously almost thirty years later in 1890. The poem can be seen as a defense of her deliberate withdrawal from society and of her unconventional life choices.

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Much Madness is divinest Sense—
To a discerning Eye—
Much Sense—the starkest Madness—
’Tis the Majority
In this as All prevail—
Assent—and you are sane—
Demur—you ’re straightway dangerous—
And handled with a Chain.

Some terms explained

discerning eye – the ability to understand wisdom
starkest madness – the ultimate insanity
assent – to agree to conform
demur – to express doubt to disagree

Questions

1. According to the poet what would we the readers realize if we had ‘a discerning eye’? What opposing concepts is she asking her readers to re-consider?
2. The poem invites readers to alter their traditional definitions of madness and sanity. How does Dickinson challenge their reception of once-familiar concepts by de-familiarising them?
3. According to Dickinson what does the ‘majority’ believe? How are people treated when they ‘assent’ and how when they ‘demur’? Why does society react that way?
4. Are there other texts in your course where similar arguments are made by the author? Do you think Lennon’s ‘dreamer’ would be considered ‘mad’ by his society? Or Chief Smohalla’s men who will not work?
5. Look at your own political and social environment and identify examples where people are rewarded for obedience and punished for dissent.

Applications

1. Write a paraphrase of this poem to bring out its meaning.
2. Document this poem. Add a glossary (difficult words and terms paraphrased and explained) cite this poem (as it is within this book) and cite the book itself (a bibliographical entry).

From ‘Disability and Poetry: An Exchange’

Jennifer Bartlett John Lee Clark Jim Ferris and Jillian Weise

Jennifer Bartlett (b. 1969) is an American poet writer and disability activist. She has co-edited *Beauty Is a Verb: The New Poetry of Disability* (2011) considered a ground-breaking collection of disability poetry and essays on disability. Her most recent book is *Autobiography/Anti-Autobiography* (2014).

John Lee Clark (b. 1978) is a DeafBlind poet essayist and independent scholar from Minnesota. He has edited two anthologies *Deaf American Poetry* (2009) and *Deaf Lit Extravaganza* (2013). His latest book is a collection of essays called *Where I Stand: On the Signing Community and My DeafBlind Experience* (2014).

Jim Ferris (b. 1954) is an American poet performance artist and disability studies scholar. He is the author of several books on poetry and disability. In 2004 his collection of poems *Hospital Poems* was written in memory of his childhood years spent in hospitals. His groundbreaking essay ‘The Enjambed Body: A Step Toward a Crippled Poetics’ appeared in *The Georgia Review* (2004).

Jillian Weise (b. 1981) is a playwright and poet who boldly explores themes like disability and sexuality as can be seen in her first poetry collection *The Amputee's Guide to Sex* (2007). Her second book of poetry was *The Book of Goodbyes* (2013) which was awarded the Academy of American Poets. Her plays have been staged at the New York and Massachusetts theatre festivals.

The conversation below has been excerpted for the purposes of this book and features these poets speaking about their work and its relation to their disabilities. They highlight abled people's lack of insight when it comes to the artistic lives of the disabled and draw attention to the prejudiced assumptions made by abled analysts and writers alike about disabled people's relationship with beauty and aesthetics.

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John Lee Clark: When I started writing my problem was that I wasn't conscious enough. As a second-generation DeafBlind man who grew up exposed to American Sign Language (ASL) storytelling and poetry I should have gone straight to those treasuries and looted them for my English products. I didn't. This was because I was also exposed to ableism and audism in English literature. English poets are especially fond of romanticizing and demonizing both deafness and blindness equating these with silence and darkness—and death.

My gut response was to protest. If for example they waxed poetic about birdsong to emphasize how terrible it must be to be deaf I would write about how our lives are full of music in motion and how beautiful ASL is. Later while assembling Deaf American Poetry I was surprised to read so many Deaf poets writing the same things all the way back to James Nack. In his nifty 1827 poem 'The Music of Beauty' the Deaf speaker luxuriating in the visual glories of nature and the charms of his blue-eyed maid says 'I pity those who think they pity me.' He goes so far as to jeer at hearing people's 'marble eyes.' What a marvelous beginning to Deaf poetry!

Since then though protest has remained the primary mode. Perhaps it's because Deaf people's cultures and languages continue to be marginalized. Protest is a worthy logical response but it can also be limiting. Instead of the full range of our realities and imaginations we get drawn into arguments we did not choose for ourselves. For example 'visual music' and 'ASL is beautiful' are the two most common tropes in Deaf poetry working to counter audist notions of deafness and muteness meanwhile in real life Deaf people are busy cooking videochatting texting dating raising families and making transactions not all of them legal. I realized that I needed to write beyond these arguments not to leave behind our causes or obscure my identity but to claim more and more space in which we can just be.

Jim Ferris: Disability is dangerous. We represent danger to the normate world and rightly so. Disabled people live closer to the edge. We are more vulnerable or perhaps it is that we show our human vulnerability without being able to hide it in the ways that nondisabled people can hide and deny the vulnerability that is an essential part of being human.

But there is something glorious in being considered so odd so marginal to society. Disability brings with it a wonderful range of remarkable and powerful vantage points. It is so much easier to see when you can gain a little distance a little perspective. Some of what we see is peculiar to disability as suggested in Stephen Kuusisto's 'Harvest' in which the speaker admires 'the white moon of the morning /even if my eyes tell me there are two moons.' But most of what we perceive isn't peculiar to disability—it's peculiar to human life. And that's what we need to be writing.

We. I presume I claim an 'us' even though there are myriad ways of embodying (and denying) disability and no two disabled people's experiences are the same. Disabled people are well schooled whether impairment is acquired early or late to identify with and aspire to be as much like nondisabled people as possible.

But if we don't claim our difference if we don't write disability the normies will keep doing it for us. It is crucial that we don't keep leaving the field to them even when we love them. Even when they tell us it's for our own good.

I love John's desire 'to claim more and more space in which we can just be.' And Jennifer's point that identities are always complex and variable is crucial. Who 'we' are is always shifting. Is disability or whiteness or maleness most salient in this moment? Or poetness vegetarian-ness musician-ness or on and on? I don't demand that poetry or any other art form serve utilitarian goals however laudable they might be. But I do want poetry including my own to open the world to pay attention to what is without getting stuck there.

I turn to poetry to help me to think to feel to perceive. I'm not sure if I could write long enough to list all the poets who have influenced me. But if I can give readers and listeners a little different way to perceive to feel to make sense of the things we only ever know partially then perhaps I'm doing a little something worthwhile.

Jillian Weise: I like John's point: 'We get drawn into arguments we did not choose for ourselves.' Sometimes I feel like I would rather talk about Kathy Acker. But what does the word 'disability' mean? Is it useful to me? Can I get some heat from it? I am reminded of what Borges said to his nephew 'If you behave I'll give you permission to think of a bear.' Most often I think about disability when I am asked to think about it. Then I feel an obligation to behave.

Yes there is ableism. One able-bodied writer said to me ‘Jillian do you know why we use disabled speakers?’ Do tell Grandmaster. ‘Because all writers are outsiders and disabled speakers are the most outsider.’ Noted. But I also hear this kind of thing: another writer once wrote to me ‘I wish your book was not so dominated by disability poems.’ And there’s the trap of ableism: disability is for able-bodied writers to write because it’s easy for them and they don’t have to think too hard about it but disabled writers should stay out of it altogether.

And the metaphors. The moon is blind. The sky is deaf. My love is lame. Your death is a phantom limb. This is a complaint about bad poetry more than ableism. Can we agree that in 2014 disability stereotypes and clichéd metaphors make bad poetry? As Rosemarie Garland-Thomson writes ‘the always overdetermined metaphoric uses of disability efface and distort the lived experience of people with disabilities evacuating the political significance of our lives.’ Or is it too soon to come to this agreement? Will it take time? I hope one day editors reject these poems.

For the full length version visit:

https://www.poetryfoundation.org/poetrymagazine/articles/70179/disability-and-poetry

Some terms explained

ableism – discrimination in favour of able-bodied people
audism – discrimination in favour of those who can hear negative stigma against deafness
to romanticize – to describe something as more attractive than it really is
to demonize – to portray something as more evil or threatening than it really is
to wax poetic – to praise using exaggerated language
ASL (American Sign Language) – a system of signing for deaf peopledifferent countries usually have their own sign languages
to marginalize – to treat a person or group or idea as unimportant and worthless
to limit – to restrict to reduce the power of something
trope – a theme that repeats itself usually in art or culture
to counter – to show disagreement to present an opposing opinion or idea
audist – a person who believes that deaf people are inferior to those who can hear
to obscure – to prevent from being understood to conceal
normate – that which is considered ‘normal’
marginal – less important
vantage point – a physical or mental position that allows the clearest view of a thing or an idea
myriad – very large numbers a large variety
to embody – to express to represent

well schooled –well educated well trained
impairment – disability
to aspire – to try to achieve
normies – 'normal'people people without physical disabilities
salient – most noticeable or important
utilitarian – useful or practical rather than attractive
laudable – worthy of praise
to perceive – to understand
obligation – duty something you feel you must do
able-bodied – without physical disability
outsider – a person who does not belong one who is excluded
dominated by – full of excessively influenced by
metaphor – a figure of speech that indirectly compares two thing through images
phantom limb – a sensation experienced by someone who has had a limb amputated who feels that the limb is still there
stereotype – an oversimplified belief about something
cliché – an overused phrase or opinion
overdetermined – overused unnecessarily repeated
to efface – to erase to ignore
to distort – to misrepresent
to evacuate – to leave empty

Questions

1. According to John Lee Clark how to abled poets usually represent deafness and blindness in their poetry? What is meant by 'romanticizing' and 'demonizing'?
2. This conversation introduces readers to a few new terms such as 'ableism' and 'audism'. Why do you think disabled poets are making readers aware of these new concepts?
3. Clark says that deaf poets look for 'music in motion'. How does ASL (American Sign Language) provide that music? Watch someone using ASL on the internet to help you see the grace of those movements.
4. Deaf poets find music in visual beauty. How does this counter the common assumption that deaf people do not have access to music?
5. Clark feels that by constantly protesting disabled writers get 'drawn into arguments' they did not choose for themselves. What does he mean by that statement?
6. Clark recommends that disabled writers should move beyond protest not in order to leave it behind but to express the other aspects of their lives. What are those aspects and why does Clark want disabled authors to shift their focus away from protest?
7. Jim Ferris states 'Disability is dangerous.' What does he mean by that statement?
8. Ferris questions his own use of the word 'we' to describe disabled people's view and feelings. He feels 'we need to claim our differences.' Why does he

feel that ‘we’ might be a limiting word? Why does he say ‘who ‘we’ are is always shifting’?
9. Explain the statement ‘if we don’t write disability the normies will keep doing it for us’.
10. Ferris wants readers toreceive disabled poetry by feeling and experiencing differently. Why do you think he stresses on newness of thoughts and ideas?
11. Jillian Weise points out a contradiction: able-bodies writers are willing to write about disability but they want disabled writers to avoid a display of disability. Why do you think this is the case?
12. Weise hopes that one day poems that use clichéd disability metaphors will be rejected as bad poetry. Why do you think such clichés ‘distort the lived experience of people with disabilities’?
13. How can able-bodied readers alter their reception of disability based on the ideas discussed in this conversation?

Applications

1. Write a summary of this conversation so that a reader gets an overview of the main arguments.
2. Consider the idea of ‘architectural amnesia’ which indicates that most buildings are constructed in complete disregard for the needs of people with different disabilities. Use your own observations of the buildings around you to find examples. Then write a letter to your able-bodied friend drawing her attention to this issue.

The Eyes Have It

Ruskin Bond

I had the train compartment to myself up to Rohana then a girl got in. The couple who saw her off were probably her parents. They seemed very anxious about her comfort and the woman gave the girl detailed instructions as to where to keep her things when not to lean out of windows and how to avoid speaking to strangers.

They called their goodbyes and the train pulled out of the station. As I was totally blind at the time my eyes sensitive only to light and darkness I was unable to tell what the girl looked like. But I knew she wore slippers from the way they slapped against her heels.

It would take me some time to discover something about her looks and perhaps I never would. But I liked the sound of her voice and even the sound of her slippers.

'Are you going all the way to Dehra? I asked.

I must have been sitting in a dark corner because my voice startled her. She gave a little exclamation and said I didn't know anyone else was here.'

Well it often happens that people with good eyesight fail to see what is right in front of them. They have too much to take in I suppose. Whereas people who cannot see (or see very little) have to take in only the essentials whatever registers tellingly on their remaining senses.

I didn't see you either' I said. 'But I heard you come in.'

I wondered if I would be able to prevent her from discovering that I was blind. Provided I keep to my seat I thought it shouldn't be too difficult. The girl said I am getting off at Saharanpur. My aunt is meeting me there.'

‘Then I had better not get too familiar’ I replied. 'Aunts are usually formidable creatures.'

'Where are you going?' she asked. 'To Dehra and then to Mussoorie.'

'Oh how lucky you are. I wish I were going to Mussoorie. I love the hills. Especially in October.'

'Yes this is the best time' I said calling on my memories. ‘The hills are covered with wild dahlias the sun is delicious and at night you can sit in front of a log fire and drink a little brandy. Most of the tourists have gone and the roads are quiet and almost deserted. Yes October is the best time.'

She was silent. I wondered if my words had touched her or whether she thought me a romantic fool. Then I made a mistake. 'What is it like outside?' I asked.

She seemed to find nothing strange in the question. Had she noticed already that I could not see? But her next question removed my doubts. 'Why don't you look out of the window?' she asked.

I moved easily along the berth and felt for the window ledge. The window was open and I faced it making a pretence of studying the landscape. I heard the panting of the engine the rumble of the wheels and in my mind's eye I could see telegraph posts flashing by. 'Have you noticed' I ventured 'that the trees seem to be moving while we seem to be standing still?'

‘That always happens' she said. 'Do you see any animals?'

'No' I answered quite confidently. I knew that there were hardly any animals left in the forests near Dehra.I turned from the window and faced the girl and for a while we sat in silence.

'You have an interesting face' I remarked. I was becoming quite daring but it was a safe remark. Few girls can resist flattery. She laughed pleasantly—a clear ringing laugh.

'It's nice to be told I have an interesting face. I'm tired of people telling me I have a pretty face.'Oh so you do have a pretty face thought I. And aloud I said: 'Well an interesting face can also be pretty.'

'You are a very gallant young man' she said. 'But why are you so serious?'

I thought then that I would try to laugh for her but the thought of laughter only made me feel troubled and lonely. 'We'll soon be at your station' I said.

'Thank goodness it's a short journey. I can't bear to sit in a train for more than two or three hours.'

Yet I was prepared to sit there for almost any length of time just to listen to her talking. Her voice had the sparkle of a mountain stream. As soon as she left the train she would forget our brief encounter. But it would stay with me for the rest of the journey and for some time after.

The engine's whistle shrieked the carriage wheels changed their sound and rhythm the girl got up and began to collect her things. I wondered if she wore her hair in a bun or if it was plaited. Perhaps it was hanging loose over her shoulders. Or was it cut very short?

The train drew slowly into the station. Outside there was the shouting of porters and vendors and a high-pitched female voice near the carriage door. That voice must have belonged to the girl's aunt.

'Goodbye' the girl said.

She was standing very close to me. So close that the perfume from her hair was tantalizing. I wanted to raise my hand and touch her hair but she moved away. Only the scent of perfume still lingered where she had stood.

There was some confusion in the doorway. A man getting into the compartment stammered an apology. Then the door banged and the world was shut out again. I returned to my berth. The guard blew his whistle and we moved off. Once again I had a game to play and a new fellow traveller.

The train gathered speed the wheels took up their song the carriage groaned and shook. I found the window and sat in front of it staring into the daylight that was darkness for me.So many things were happening outside the window. It could be a fascinating game guessing what went on out there.

The man who had entered the compartment broke into my reverie.

'You must be disappointed' he said. 'I'm not nearly as attractive a travelling companion as the one who just left.'

'She was an interesting girl' I said. 'Can you tell me—did she keep her hair long or short?'

'I don't remember' he said sounding puzzled. 'It was her eyes I noticed not her hair. She had beautiful eyes but they were of no use to her. She was completely blind. Didn't you notice?

Questions

1. How does the blind author gather information about the girl's physical appearance? Which 'remaining senses' does he use?
2. What are the strategies Bond uses to conceal his blindness from the girl? Do those strategies seem to work?
3. Notice that we as readers know only as much as Bond does. Since the story is written by a blind person we too are lacking visual information about the girl. Is the author's 'blind' account adequate for abled readers? Are we able to imagine the girl through non-visual senses? What does that tell us about our assumptions about blindness?
4. The revelation at the end that the girl was blind too clearly takes the writer (and the reader) by surprise. Why do you think he fails to notice the girl's blindness?
5. In this story Bond seems to be focusing on physical blindness. Does he also draw attention to other kinds of blindness? If so how so?
6. If we consider that blindness can be a state of mind how does that realization help us reconsider our beliefs about disability?

Application

> Undertake a close reading of the story and make a list of all vocabulary and imagery that involves non-visual descriptions.

SECTION 4 – EVALUATION

The previous sections discussed the various ways in which to interpret an argument: by examining the features of the text by analysing the positions and biases of the author by studying the persuasive strategies used by the author and by being critically aware of our own beliefs and predispositions.

In this section we will see how we as readers can employ all these interpretive skills to determine the central purpose of the text. We introduce you to an important word: thesis. Every argument has a thesis or a theory. We can go back to Aristotle and the ancient Greeks who formulated the importance of a thesis in all arguments. The thesis is a statement of purpose. This statement can be found clearly stated early on in the text (in the case of prose writing such as articles essays or opinion pieces) or may be inferred as an implied statement (in the case of poetry or fictional texts like short stories and novels) answering the question: What am I going to prove in this text? What do I believe? What do I want you to recognize by the end of my text?

You must assume that each piece of communication each text seeks to persuade its audience. For example if I write an article on child labour my purpose is to convince you of my opinions on the subject. If I write a poem about the beauty of the Bengal landscape I want my readers to feel the way I do about Bengal. If I write a short story on the devastation of the World War II I intend that my audience should react to my views with sympathy and agreement.

Ultimately you as a reader are analysing the text in order to determine the following: What is the writer's thesis (whether stated or implied)? What strategies does the writer use to convince us of the validity of the thesis?

Readings for Section 4

Ain't I a Woman?

Sojourner Truth

Sojourner Truth (born Isabella (Belle) Baumfree 1797-1883) was born into slavery in upstate New York and was the youngest child of James and Elizabeth Baumfree. Like most enslaved people her family was broken up several times when she and her siblings were repeatedly sold. In 1826 when she was around thirty years old she escaped to freedom with her infant daughter Sophie. A year later she filed a case to free her son Peter who had been sold in Alabama. She won the case and Peter was returned to her.

In her forties she renamed herself Sojourner Truth because she felt it was her calling to travel and tell her story. She became an activist for abolition and women's rights and continued doing so until her death. This ex-slave and fighter for women's rights and the abolition of slavery was well known as an articulate orator.

'Ain't I a Woman' is Truth's most famous speech delivered in 1851 at the Women's Rights Convention in Akron Ohio. Because the speech was never formally writtenseveral versions exist as people related it from memory. The following is an eye-witness account by Frances Gage an abolitionist and president of the Convention who wrote the account in 1863. 'Ain't I a Woman?' made a great impact at the Convention and has become a classic expression of women's rights.

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Several ministers attended the second day of the Woman's Rights Convention and were not shy in voicing their opinion of man's superiority over women. One claimed 'superior intellect' one spoke of the 'manhood of Christ' and still another referred to the 'sin of our first mother'. Suddenly Sojourner Truth rose from her seat in the corner of the church. 'For God's sake Mrs. Gage don't let her speak!' half a dozen women whispered loudly fearing that their cause would be mixed up with Abolition.

Sojourner walked to the podium and slowly took off her sunbonnet. Her six-foot frame towered over the audience. She began to speak in her deep resonant voice:

'Well children where there is so much racket there must be something out of kilter. I think between the Negroes of the South and the women of the North – all talking about rights – the white men will be in a fix pretty soon. But what's all this talking about?'

Sojourner pointed to one of the ministers. 'That man over there says that women need to be helped into carriages and lifted over ditches and to have the best place everywhere. Nobody ever helps me into carriages or over mud-puddles or gives me any best place! And ain't I a woman?'

Sojourner raised herself to her full height. ‘Look at me! Look at my arm.’ She bared her right arm and flexed her powerful muscles. ‘I have plowed I have planted and I have gathered into barns. And no man could head me. And ain't I a woman?’

‘I could work as much and eat as much as man – when I could get it – and bear the lash as well! And ain't I a woman? I have borne children and seen most of them sold into slavery and when I cried out with a mother's grief none but Jesus heard me. And ain't I a woman?’ The women in the audience began to cheer wildly.

‘She pointed to another minister. ‘He talks about this thing in the head. What's that they call it?’ ‘Intellect’ whispered a woman nearby.

‘That's it honey. What’s intellect got to do with women's rights or black folks’ rights? If my cup won't hold but a pint and yours holds a quart wouldn’t you be mean not to let me have my little half-measure full?

‘That little man in black there! He says women can't have as much rights as men ’cause Christ wasn't a woman.’ She stood with outstretched arms and eyes of fire. ‘Where did your Christ come from? Where did your Christ come from?’ she thundered again. ‘From God and a Woman! Man had nothing to do with him!’

The entire church now roared with deafening applause.

‘If the first woman God ever made was strong enough to turn the world upside down all alone these women together ought to be able to turn it back and get it right-side up again. And now that they are asking to do it the men better let them.

‘Obliged to you for hearing me and now old Sojourner ain't got nothing more to say.’

Questions

1. What is the central argument of the speech? What is Truth trying to prove here? Can you express Truth’s thesis in two or three sentences?
2. Why does Truth repeat the phrase ‘ain’t I a woman’ so many times? Why does she think people might have difficulty considering her a woman? How does her physical appearance add value and effectiveness to her argument?
3. Note that although Truth is speaking at a woman’s rights convention her audience is not necessarily made up of friendly supporters. Who among the audience would be considered hostile to her presence and her words and why?
4. Why do you think Truth addresses the skeptical members of the audience directly? How would you evaluate her strategy of singling out her most difficult listeners? Does this tell you something about her argumentative techniques?
5. How does traditional society define the term ‘woman’? What characteristics are associated with the word?
6. How does Truth’s background as a black woman and an ex-slave help her make her point?

7. How would you evaluate the success of Truth's speech? Would it be by speculating on how many minds she may have changed? Could it be valued simply as a morale-raising speech in a meeting for women's rights?

Applications

1. Write an essay interpreting the verbal and non-verbal ways in which public speakerscommunicate with their audiences. Consider politicians TV anchors religious preachers teachers etc. How do such communicators use repetition humour and gesture to make their arguments?
2. Write a simpler version of this speech (a paraphrase in modern English) in order to facilitate comprehension for readers who may find the American colloquialisms difficult to understand.

Imagine

John Lennon

John Lennon (1940-1980) was a British singer songwriter and pacifist remembered as the co-founder of the rock-and-roll band The Beatles which achieved worldwide fame in the 1960s. The mid-sixties and early seventies in Britain were full of social turmoil and political upheaval and the music of the Beatles often critiqued what young people saw as the materialism and greed of mainstream society.

'Imagine' is one of Lennon's most famous songs and also rated by British and American music magazines and analysts as one of the best songs ever written. In the song the poet attempts to move his audience away from the ugliness of their socio-political environment into an imaginary world where all social problemsare miraculously erased.

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Imagine there's no heaven
It's easy if you try
No hell below us
Above us only sky
Imagine all the people
Living for today...

Imagine there's no countries
It isn't hard to do

Nothing to kill or die for
And no religion too
Imagine all the people
Living life in peace...

You may say I'm a dreamer
But I'm not the only one
I hope someday you'll join us
And the world will be as one

Imagine no possessions
I wonder if you can
No need for greed or hunger
A brotherhood of man
Imagine all the people
Sharing all the world...

You may say I'm a dreamer
But I'm not the only one
I hope someday you'll join us
And the world will live as one.

Note:

'Utopia' is an imaginary ideal world where common social and political problems do not exist. Utopic texts (poems stories plays or songs) picture a world far removed from the real environment of the author and the audience. This song imagines one such world.

Questions

1. In describing various kinds of worlds why does the poet use the word 'imagine'? Why doesn't he ask his audience to 'describe' such worlds?
2. There are three things the poet asks the reader to imagine. What are those things?
3. When Lennon asks us to imagine a world without heaven or hell which major social belief is he questioning? Can you think of words in your native languages that have the same meanings as 'heaven' and 'hell'?
4. Why does the poet want a world without countries? What are the negative impacts of boundaries in our present world? Why does he feel that peace is not possible in a world with countries?
5. Why does the poet feel that he will be perceived as a 'dreamer'? What are the implications of the word? How is dreaming unsuitable in the 'real' world?
6. The word 'utopia' refers to an ideal perfect state or place. How is this a utopian poem?

7. Why do you think Lennon chose to write a utopic song? In what social circumstances might a utopic text be useful or meaningful? By evaluating this utopic world how does Lennon implicitly invite his audience to evaluate the 'real' present world?

Application

Write an open letter to the prime minister (to be published in a newspaper) describing your vision for an ideal society. Focus on the eradication of problems that are pertinent to your society such as poverty corruption pollution and crime (including crimes against women).

Girls

Mrinal Pande

Mrinal Pande (b. 1946) is an Indian television personality journalist and author and till recently chief editor of the Hindi daily *Hindustan*. She left *Hindustan* in 2009 and was appointed the following year chairperson of Prasar Bharati the apex body of the official Indian Broadcast Media a post she occupied until 2014. She also hosts a weekly interview show titled 'BaatonBaaton Mein' on Lok Sabha TV. Earlier she worked for Doordarshan and Star News. She has also written a few short stories and was the editor of the popular women's magazine *Vama* from 1984-87.

'Girls' (published in Hindi *Dharmyug*magazine in 1983 and translated into English for *Manushi*the same year)describes the psychological influence of patriarchy on women from a very young age when they constantly hear conversations about their being unwanted and being considered burdens. Although the protagonist of the story is a lively imaginative and mischievous eight-year-old girl the plight of women of all ages is reflected here including the nani the maasi the mami and the protagonist's older sister.

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The day we left with Ma for Nani's house Babu broke a surahi. I don't know whether he did it on purpose or by accident but anyway the floor was flooded with water. Ma held up her sari and called Saru's mother—who was trying to eavesdrop from the adjacent room—to mop up the water because if someone were to slip and break the bones it would be yet another problem. To Ma everything in life was a problem. As far as she was concerned whether we were at home or at school ill or just playing around we were a problem. While mopping the floor Saru's mother looked up at Ma and asked ‘This time you'll be away for at least three months won't you?’ Ma squatted down and said ‘Yes they won't allow me to come back sooner.’ She turned to me and ordered me to go out and play. I always seemed to turn up at the wrong time and at the wrong place. As I was leaving the room I managed to pick up a piece of the broken surahi which I enjoyed sucking and I overheard Ma addressing either Saru's mother or the cobwebs hanging from the roof: ‘I hope it's a boy this time. It will relieve me of the nuisance of going through another pregnancy.’ I could just imagine Saru's mother in her usual manner shaking her head and saying ‘Why not?... Why not?...’

When we reached the station I scrambled on to the train fought my way through people and luggage and secured a place next to the window. Triumphantly I stuck my tongue out at everyone and went ‘Eee…eee.’ But when I noticed Ma's gaze turning towards me I immediately started chanting the alphabet ‘Eee for Imli Ee for Eekh.’ Ma was actually not looking at me though because she was preoccupied with all her problems. She had to mind the luggage the wobbling surahi the three of us and cope with the exhaustion of pregnancy as well. At one of the stations we bought a lot of samosas filled with chillies. Just when we were buying them a woman was making her child urinate through the next window. The sight made me feel quite nauseous and I couldn't eat my samosa so I gave it to Ma instead. Meanwhile I crushed a piece of potato which was lying on the seat into the shape of an insect to frighten my younger sister. She screamed Ma smacked me and I started to cry as well. My elder sister was irritated and said ‘Oh what a nuisance you are!’ Despite her irritation I knew that it was only my elder sister who really loved me everyone else was horrible.

Mama was waiting to receive us at the station. On the way to Nani's I sat next to Mami and noticed the rubies in her ear lobes bobbing up and down while she chewed paan. Everytime the driver pressed the jeep's horn my sisters and I would scream in unison ‘Poo...poo.’ The driver was amused at our screaming and when we reached the house he lifted me and my younger sister out of the jeep. He had a huge moustache which smelt of tea and bidis and wore a uniform made of coarse wool which tickled me and made me feel sleepy. When thesurahi was lifted out of the jeep it overturned and once again there was water everywhere. This incident reminded me so much of Babu that absent-mindedly I trod hard on my younger sister's sandal nearly tripping her up. ‘You are the cause of all my problems!’ Ma hissed at me through tightly clenched teeth so that no one could hear. She then grabbed hold of my arm as if to prevent me from falling over but actually pressed it so hard that my shoulder hurt.

I thought of Babu because whenever we came to Nani's house he never accompanied us. And as soon as we arrived Ma would be lost in the company of Masis Mamis Nani and old maidservants. If you tried going near her during the day someone or other would say ‘Let the poor thing have some rest at least while she is here.’ Ma too would put on a pathetic act as if we always harassed her at home. I felt disgusted at the thought of entering Nani's house so I deliberately loitered near the bushes. Then I heard someone mentioning my name inside the house and saying ‘Now where has she disappeared?’

I entered the house along with the dogand saw Nani sitting with Mama's son on her lap. As soon as she saw the dog she shooed it away because to her all animals were as untouchables. The dog used to being reprimanded tucked its tail between its legs and went out. I was told to bend down and touch Nani's feet. Someone from the familysaid ‘Not like that...bend properly. You are born a girl and you will have to bend for the rest of your life so you might as well learn.’ Nani blessed me by waving her hand over my bowed back and said ‘This girl hasn't grown taller. Who would believe she is eight years old?’

‘Oh what a nuisance this is’ Ma kept complaining. The old lady from the neighbourhood who had come to see Ma told Nani ‘This time Lali will definitely have a boy. Just look at her complexion—when she was expecting the girls it was pink but now it has a tinge of yellow. I am sure it will be a boy this time.’

‘Who knows perhaps even this time...’ moaned Ma as she put on a pathetic expression and began paring her nails.

‘Is there anyone to cook for your husband?’ asked the old lady. Her question set me thinking about Babu how good he smelt and the softness of his lap. And how when we came here Ma did not allow us to lie in her lap for too long and complained ‘Ugh! Oh! My bones are aching my sari is all crushed. Get up now. I have such a lot of work to do and to top it all there is this huge nuisance. Come on get up.’

Nani folded her hands and prayed: ‘Oh Goddess protect my honour! At least this time let her take a son back from her parents' home’. At the end of her prayer she dried her tears with her pallav.

From the corner of my eyes I could see that my sisters were fast asleep. All the lights had been switched off and the room was flooded with moonlight. Tulsa Dai was applying oil to the soles of Ma's feet and saying ‘If it's a boy this time I will demand a sari with stainless steel zari.’

‘If I have a boy this time then I will be relieved of this burden forever’ she tells Tulsa Dai and then adds ‘You can go home now your children must be waiting for you. Be sure you put the oil vessel under the bed otherwise one of these kids will kick it over in the morning....’ Ah a bad omen. Whenever Ma left a sentence unfinished it seemed to loom in the air like the ticking of the clock. I wonder why grown-ups always complete their sentences when they are talking about pleasant things but always leave them unfinished if it is something unpleasant. Like ‘Ah a woman's fate....’ Or ‘Oh three girls....’ There's always a silence after these half statements.

There's a bright star in the sky. Is that the Dhruva star? Babu used to say that if I worked hard I could become anything I wanted just as Dhruva became a star. ‘But I can't become a boy can I?’ I once asked obstinately. I was surprised at Babu's reaction when he put on a serious look and said sternly ‘Don't argue with your elders now.’ I find it difficult to understand them. My elder sister says one should never trust grownups because if they want to know something they will prise it out of you by hook or by crook but they themselves will never tell you a thing.

It's true nobody ever tells us anything. In this place it's when we go to sleep that the world of the elders awakens opening like a magic casket. I want to stay awake and listen I don't know why I fall asleep halfway through. I wonder whose voice it is now it seems as if someone is crying in suppressed tones. Is it ChottiMasi? ‘I don't get as much respect as a dog does in that house’ she tells Ma. I wonder where she is treated worse than a dog then I hear Ma telling her ‘All of us suffer like that one just has to endure it.’ My eyes shut and I fall asleep.

The next morning when everyone is having breakfast I ask Ma what ‘endure’ means. I remind her by asking what does ChottiMasi have to endure? I get one tight slap then another but before Ma strikes me again Mami saves me and says ‘Let it be. She is only a child after all.’‘She is no child she is a witch’ says Ma as her stomach wobbles in anger. ‘She's always listening on the sly to elders talking. Heaven knows what will become of her.’

When I go into the garden my elder sister throws the flowers she has gathered at me. ‘Oh...you! I have told you a hundred times not to question grown-ups. If you keep on like this one day these people will beat you so hard you will die.’‘I will ask questions. I will. I will’ I answer crying. ‘Then go and die’ says my elder sister and continues to thread a garland for Nani's Gopalji. Nani stands by her and says loudly ‘You are my precious Lakshmi’ with the intention that I should hear. In the afternoons I tell the younger children horror stories of ghosts and demons who lived in the walnut tree. I tell them that if they should wake up at twelve o'clock on a full-moon night they would see children being bathed in blood. They would also hear the ghosts speaking through their noses which at first is difficult to follow. The children follow me all over the house like mice following the Pied Piper.

‘Move aside’ says Hari's mother who is carrying a tray laden with glasses of tea into the room. ‘Move. This is not for you it's for the grown-ups. Move out of myway.’Hari's mother's nose is like a frog's and her eyebrows meet above her nose. Whenever she laughs her cheeks hang loose like bats. ‘Do move aside’ she says to me again. ‘I won't’ I say and try to block her way. ‘I'll only move if you say girls are nice.’‘All right all right I have said it so now move out of the way’ says Hari's mother. ‘No’ I persist ‘say it properly.’

‘Oh Hari's Ma what's happening?’ asked Maasi irritably from the room. ‘Are you going to bring the tea next year or what?’ Hari’s mother knits her thick eyebrows together and says ‘This Lali's middle daughter won't let me....’ She starts laughing and as she does so her frog-like nose bobs up and down. I can hear Ma naming me and saying ‘That girl must be harassing her. She was born only to plague my life.’ Someone in the room advises her that she should not get angry in her condition.

For a long time I sit outside the house watching the birds flying and wishing that I had been born a bird. ‘Do mother birds too think their girl birds are inferior?’ I wonder. Then I hear a voice calling ‘Where has she gone?’ and I know someone is searching for me. I hide behind the wall where no one can ever find me. I wish that somewhere anywhere I could find that magic betel nut which would make me invisible as soon as I put it in my mouth. What wonderful fun that would be!

‘Where are you? Girls?’ calls Nani with a tray of crimson powder in her hands. In front of her there is a dish of halwa and a plate filled with puris she has prepared as offerings to the Devi on Ashtami day. A mat has been spread in front of her for us to sit on. ‘Come on girls let me put the teeka on your foreheads.’ She lights the camphor for aarti. ‘Come now let me do aarti to all of you.’ My two sisters and Maama's beautiful daughters sit cross-legged in front of Nani. She puts a teeka on each forehead and then rings a bell. Exactly like the guard on the train. After the bell rings she blows the conch. ‘Poo...ooo’. I am suddenly transformed into a railway engine and race around the ledge of the courtyard. I shout ‘Come on pay your fares to go to Calcutta. Poo...ooo.’

In the background I hear Nani saying ‘Come on dear let me put the teeka on you. You are my Kanyakumari aren't you?’

‘No’ I retort ‘I am an engine.’ Mami's son claps his hands with excitement and says ‘Oh an engine an engine!’

Suddenly I see Ma waddling towards me with a clenched fist and my stomach grows tight with fear. Her face is filled with rage. ‘I'll make an engine out of you this very minute.’

The elderly neighbour intervenes catches hold of Ma’s hand and says ‘Have you gone mad Lali?’ She signals to me to obey and adds ‘She's after all a child a Kanyakumari. Today is Ashtami the Devi's day you mustn't hit a Kanyakumari it is a sin.’

I jump down from the ledge with a thud and see Nani serving the other girls halwa-puri with the tightly clenched mouth.

‘Go on. Take the prasad from Nani. Why do you make your mother cry when she is in this condition?’Masi asked me irritably.

‘When you people don't love girls why do you pretend to worship them?’ My voice breaks into a sob and I feel so furious with myself that I want to swallow the burning camphor to choke my treacherous throat. I want to ask ‘Why’ again but don't risk it because I am afraid I will start to cry. I don't want to cry in front of them.

Hari's mother addresses the wall saying ‘Just listen to her. What a temper for a girl to show!’

Nani is distributing a rupee and a quarter to each girl. I notice the mark of the crimson powder on the tip of her thumb like a bloodstain.

I start moving back towards the wall and screaming ‘I don't want all the halwa-puri teeka or money. I don't want to be a goddess.’ I screamed so loudly that the pigeons pecking at the scattered grain in the courtyard took off in a flurry as if a bullet had been fired somewhere.

Questions

1. The young protagonist of the story is always getting into trouble with her mother. What are the different kinds of things that get her scolded and beaten through the story? Is she sometimes at fault?
2. Why does Mrinal Pande use such a young girl as her storyteller? Would the central idea of this story the critique of the desire for a male child be more effectively narrated by one of the older women? What are the uses of seeing the world through the eyes of a child?
3. What is the girl’s relationship with her father? Is it her father who allows her to think independently and to ask questions that her sister tells her she will get beaten for?
4. How do we evaluate a story that is told humourouslybut ends with this penultimate line: ‘Nani is distributing a rupee and a quarter to each girl. I notice the mark of the crimson powder on the tip of her thumb like bloodstain’?
5. Evaluate the last line of the story. What is the significance of the sound of pigeon wings being compared to the sound of a bullet?

Applications

1. Write a public speech on female infanticide.
2. Since this story was first written in Hindi what comprehension problems would a non-Hindi speaking reader face while reading it in English? How could a good translation bridge the communication gap? Focus on words and phrases that are difficult to translate.

SECTION 5 – ANALYSIS

So far you have studied the various ways in which a writer presents an opinion and argument or a point of view. You have also looked at the levels at which you as the reader/audience can critically read the text. This section will draw your attention to a vital task that is performed by all students and researchers in all academic disciplines. This task is that of writing.

As students we are required to demonstrate our understanding of texts through the written word in assignments presentations tests and examination papers. No matter with what smartness and sophistication you have analysed texts you need to convert that knowledge into essays for your teachers peers and examiners to evaluate. In this case *you* are the author writing what is called a 'rhetorical analysis' of the texts in your course. It is this rhetorical analysis that the examiner will evaluate and grade.

How do you begin a rhetorical analysis essay? You will start with an introduction explaining the historical social and cultural context of the text in question. When was the text written by whom and for whom? Next you will state your argument. What aspect of the text is this essay (your essay) about to examine? What is *your thesis* about the text? Thus your thesis will appear at the end of your introduction. Remember just as you search for other writer's theses at the beginning of their texts you too must announce your thesis at the end of the very first paragraph of your essay.

Once you have done so what remains is for you to use intelligent and logical paragraphing to present at least three different aspects of analysis. Use all the interpretive skills we discussed in earlier parts of this book. Remember just as you expect other writers to furnish evidence of their findings so too in your rhetorical analysis your readers/examiners expect you to prove your points through definitions examples comparisons and logical and reliable arguments.

Once you have substantiated your claims write a brief conclusion to wind up the argument and to suggest elements for further investigation and study.

When you look at the texts in this section think also about how you might write a rhetorical analysis on them where you are the writer the examiner is your audience and your subject is the thorough analysis of the text.

Readings for Section 5

Bosom Friend

Hira Bansode

Hira Bansode (b. 1939) one of the best-known woman Dalit poets in Marathi brought a feminist slant to Dalit poetry. Born into a Mahar family a Kamble in a village of Pune district she moved to Mumbai as a child when her father became a municipal worker. She studied up to the ninth standard before being married at the age of 14. Encouraged by her husband and father-in-law she completed her S. S. C. and then began working as a railway clerk a jobshe still holds. It took thirteen years of endeavor for her to take the B.A. and M.A. in Marathi.

'Bosom Friend' is one of her most famous poems. The ironic title of the poem points to the hypocrisy of Indian society in its treatment of issues of caste. The poem recalls the centuries of caste oppression that forms the history of India.

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Today you came over to dinner for the first time
You not only came you forgot your caste and came
Usually women don't forget that tradition of inequality
But you came with a mind large as the sky to my pocket size house
I thought you had ripped all those caste things
You came bridging that chasm that divides us
Truly friend I was really happy
With the naïve devotion of Shabari I arranged the food on your plate
But the moment you looked at the plate your face changed
With a smirk you said Oh My – Do you serve chutnykoshambir this way?
You still don't know how to serve food
Truly you folk will never improve.

I was ashamed really ashamed
My hand which had just touched the sky was knocked down
I was silent
Toward the end of the meal you asked
What's this? Don't you serve buttermilk or yoghurt with the last course of rice?
Oh My Dear we can't do without that…
The last bit of my courage fell away like a falling star
I was sad then numb
But the next moment I came back to life

A stone dropped in the water stirs up things on the bottom
So my memories swam up in my mind
Dear Friend – You ask about buttermilk and yoghurt
What/How shall I tell you?

You know in my childhood we didn't even have milk for tea much less yoghurt or buttermilk
My mother cooked on sawdust she brought from the lumberyard wiping away the smoke from her eyes
Every once in a while we might get garlic chutny on coarse bread
Otherwise we just ate bread crumbled in water
Dear Friend – Shrikhand was not even a word in our vocabulary
My nose had never smelled the fragrance of ghee
My tongue had never tasted halva basundi
Dear Friend – You have not discarded your tradition
Its roots go deep in your mind
And that's true true true
Friend – There's yoghurt on the last course of rice
Today the arrangement of food on your plate was not properly ordered
Are you going to tell me what mistakes I made?
Are you going to tell me my mistakes?

1. What does the gratitude and happiness of the protagonist of the poem tell us about the reality of her relationship with her 'bosom friend'? Why is she so happy?
2. The protagonist describes her emotions as moving from happiness to shame then to numbness and finally to coming 'back to life'. How can we analyze this journey of emotions as the journey from submission to resistance?
3. How does Hira Bansode use different kinds of food and their preparation to discuss caste discrimination? Why does she narrate her past through food to bring out her family's deprivation?
4. Analyse the conclusion of the poem: 'Are you going to tell me what mistakes I made? / Are you going to tell me my mistakes?' How do the last lines turn the tables on the guest showing her as the mistake-maker rather than the protagonist? Discuss the strategy Bansode uses to focus the reader's attention on the historic oppression of Dalits.

Application

Write a report on caste in present day Indian society. Explain the background of the caste system analyse problems that result from the system and suggest solutions. To do so design a three-fold argument (thesis). What evidence would you use in support of your argument? And finally what would be your conclusion?

An Enabling Garment

Mukul Kesavan

Mukul Kesavan (b. 1957) is an Indian historian novelist and political and social essayist. His first novel *Looking Through Glass* (1994) was recognized internationally as have his shorter pieces of writing over the years.In 2014 *The New Republic* included his *Homeless on Google Earth* in its list of the year's best books describing Kesavan as '[a] novelist and essayist a historian and poet a social commentator and public intellectual [who] commands an enviable following in the Anglophone world beyond America and Britain'. He teaches social history at Jamia Millia Islamia in Delhi.

This article was written for *The Telegraph*(Calcutta) in 2006 in which he counters British politician Jack Straw's analysis of the veil. His views are informed by his first-hand experience teaching mostly Muslim women at Jamia. The article has been abridged for the purposes of this book.

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Britain's former foreign secretary Jack Straw wrote an article in the *Lancashire Telegraph* a local newspaper that circulates in his parliamentary constituency describing his difficulty in communicating with Muslim constituents who met him with their faces veiled. He wrote that he often requested them to unveil themselves (always in the presence of another woman) so that he could read their expressions as they conversed because the point of two people meeting (as opposed to talking over the phone) was so that they could be literally face-to-face.

I teach in Jamia Millia Islamia a university in Delhi. Jamia was founded and nurtured by a remarkable group of Muslims in the early 20th century: Maulana Mohammad Ali Professor Muhammad Mujeeb and Dr Zakir Hussain. Given its history Muslims make up a much larger proportion of its student body and faculty than is usual in Indian universities. In some of my classes the attendance register lists more Muslims than non-Muslims. In the fifteen years I've taught there one or two of these Muslim students have worn the *burqa* the enveloping black garment that generally (though not always) veils the wearer's face. …

As a young lecturer I thought I might have some trouble connecting a veiled student's name with her face because it wasn't on view but the opposite was true. There were no more than one or two burqa-ed girls in any class and their conspicuousness was a kind of cue. Telling them apart wasn't an issue either: every lecturer learns that there are only two sorts of students: animated ones on the verge of asking a question and sleepwalkers a breath away from snoring. Veiled students I discovered weren't quieter than the unveiled ones just more covered up.

Did I have a view on the burqa? Yes I did. I thought it was a traditionalist hold-over something that represented the seclusion of women that would be less and less commonly worn as women entered the public world. Since the overwhelming majority of women in Jamia both students and teachers didn't wear the burqa I assumed it was vestigial. I thought the burqa was an extreme version of other forms of veiling that I had encountered within my (Hindu) family: I had aunts and cousins on my mother's side of the family who lived in Chandni Chowk and used the *anchal* of their *saris* their *ghoongats* to cover their faces in the presence of fathers-in-law and other strange men…. None of the girls in my extended family deploy their ghoonghats like their mothers did and over the years I've seen a secular decline in the incidence of burqas in Jamia….

Jack Straw is entitled to feel uneasy about the *niqab* and in a free society he is within his rights to publish his feelings. But he is unwise to request his constituents to remove their veils…he makes a mistake in assuming that the burqa is uniquely disruptive of human contact. It's much harder conversing with someone wearing dark glasses. Where Jack Straw needs lips and noses to look at I need eyes and I find it irritating even offensive when people don't do me the courtesy of shedding their goggles through a long conversation. But I don't ask them to take them off neither I imagine does Jack Straw.

Obstacles to face-to-face conversations depend on what you're used to and therefore comfortable with. Straw is probably undistracted by tiny skirts and plunging necklines but it might be harder for an Asian MP accustomed to more covered-up women to concentrate on a constituent's problems if her every move revealed (in his prudish mind) inches of intimate skin….

But Straw in his column isn't opposed to the burqa only because it obscures a woman's face he wants women to discard it because he is concerned that '..wearing the full veil was bound to make better positive relations between the two communities more difficult. It was such a visible statement of separation and of difference.'

That's a large statement and it tells us more about Straw and possibly the English attitude towards difference than it does about the burqa as an alienating symbol. I went to a Jesuit school in Delhi and I remember as a child being astonished by the cassocks the padres wore. Men in authority wearing maxis: it was very odd and ungendered and had Straw been a classmate he might have described the cassock as a visible statement of separation and of difference even an obstacle to better positive relations between two communities. But as Indians we grow up surrounded by such ripely different sorts of people that after our initial bewilderment my classmates and I decided that padres came with cassocks attached. Our acceptance of difference was so complete that when we met padres in trousers they seemed forked and lewd.

…Goodwill in the face of perceived difference is the responsibility of the beholder. A burqa is no more a statement of separation than a mini-skirt is an invitation to familiarity. The next time he walks into his surgery or settles down to blog Jack Straw might remember that.

Questions

1. According to the author what are Jack Straw's objections to the veil?
2. The author discusses the reasons why communicating with veiled women in his classes is not difficult. How does this passage challenge Jack Straw's position?
3. What is the author's opinion on the use of the burqa?
4. While discussing his views on the burqa the author refers to the use of the ghoongat by Hindu women. What do you think is his intention in drawing this comparison? What prejudices and assumptions in his readers might he be targeting through this argument?
5. Why do you think the author discusses the clothing of the Jesuit padres in his school? What connection does the author want the reader to make between padres wearing cassocks western women wearing skirts and Muslim women wearing burqas?

Application

The following statement appears at the end of this article: 'Goodwill in the face of perceived difference is the responsibility of the beholder.' Assuming that all the arguments in this article are leading to this one statement analyse the statement referring to the rest of the article for arguments reasons and examples. What are the barriers to inter-cultural communication? What are the strategies for bridging communication gaps?

The Story of An Hour

Kate Chopin

Kate Chopin (1850-1904) is considered one of the first feminist authors of the twentieth century. She is often credited for introducing the modern feminist literary movement. Chopin was following a rather conventional path as a housewife until an unfortunate tragedy—the untimely death of her husband—altered the course of her life. She became a talented and prolific short story writer.

'The Story of an Hour' (1894) is seen as a pioneering modern feminist short story one that plays a role in launching modern feminist literature in America. The reader should note the relationship of the leading figure in that story to the circumstances of Chopin's own life where the death of her own husband started a process that would ultimately push her beyond the roles of wife and mother of six to the life of an artist. 'The Story of an Hour' makes the reader analyze and challenge conventional roles for women through the twists and turns in the narration of events that take place in the short period of one hour.

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Knowing that Mrs. Mallard was afflicted with a heart trouble great care was taken to break to her as gently as possible the news of her husband's death.

It was her sister Josephine who told her in broken sentences veiled hints that revealed in half concealing. Her husband's friend Richards was there too near her. It was he who had been in the newspaper office when intelligence of the railroad disaster was received with Brently Mallard's name leading the list of 'killed.' He had only taken the time to assure himself of its truth by a second telegram and had hastened to forestall any less careful less tender friend in bearing the sad message.

She did not hear the story as many women have heard the same with a paralyzed inability to accept its significance. She wept at once with sudden wild abandonment in her sister's arms. When the storm of grief had spent itself she went away to her room alone. She would have no one follow her.

There stood facing the open window a comfortable roomy armchair. Into this she sank pressed down by a physical exhaustion that haunted her body and seemed to reach into her soul.

She could see in the open square before her house the tops of trees that were all aquiver with the new spring life. The delicious breath of rain was in the air. In the street below a peddler was crying his wares. The notes of a distant song which some one was singing reached her faintly and countless sparrows were twittering in the eaves.

There were patches of blue sky showing here and there through the clouds that had met and piled one above the other in the west facing her window.

She sat with her head thrown back upon the cushion of the chair quite motionless except when a sob came up into her throat and shook her as a child who has cried itself to sleep continues to sob in its dreams.

She was young with a fair calm face whose lines bespoke repression and even a certain strength. But now there was a dull stare in her eyes whose gaze was fixed away off yonder on one of those patches of blue sky. It was not a glance of reflection but rather indicated a suspension of intelligent thought.

There was something coming to her and she was waiting for it fearfully. What was it? She did not know it was too subtle and elusive to name. But she felt it creeping out of the sky reaching toward her through the sounds the scents the color that filled the air.

Now her bosom rose and fell tumultuously. She was beginning to recognize this thing that was approaching to possess her and she was striving to beat it back with her will--as powerless as her two white slender hands would have been. When she abandoned herself a little whispered word escaped her slightly parted lips. She said it over and over under the breath: 'free free free!' The vacant stare and the look of terror that had followed it went from her eyes. They stayed keen and bright. Her pulses beat fast and the coursing blood warmed and relaxed every inch of her body.

She did not stop to ask if it were or were not a monstrous joy that held her. A clear and exalted perception enabled her to dismiss the suggestion as trivial. She knew that she would weep again when she saw the kind tender hands folded in death the face that had never looked save with love upon her fixed and gray and dead. But she saw beyond that bitter moment a long procession of years to come that would belong to her absolutely. And she opened and spread her arms out to them in welcome.

There would be no one to live for during those coming years she would live for herself. There would be no powerful will bending hers in that blind persistence with which men and women believe they have a right to impose a private will upon a fellow-creature. A kind intention or a cruel intention made the act seem no less a crime as she looked upon it in that brief moment of illumination.

And yet she had loved him--sometimes. Often she had not. What did it matter! What could love the unsolved mystery count for in the face of this possession of self-assertion which she suddenly recognized as the strongest impulse of her being!

‘Free! Body and soul free!’ she kept whispering.

Josephine was kneeling before the closed door with her lips to the keyhole imploring for admission. ‘Louise open the door! I beg open the door--you will make yourself ill. What are you doing Louise? For heaven's sake open the door.’

‘Go away. I am not making myself ill.’ No she was drinking in a very elixir of life through that open window.

Her fancy was running riot along those days ahead of her. Spring days and summer days and all sorts of days that would be her own. She breathed a quick prayer that life might be long. It was only yesterday she had thought with a shudder that life might be long.

She arose at length and opened the door to her sister's importunities. There was a feverish triumph in her eyes and she carried herself unwittingly like a goddess of Victory. She clasped her sister's waist and together they descended the stairs. Richards stood waiting for them at the bottom.

Some one was opening the front door with a latchkey. It was Brently Mallard who entered a little travel-stained composedly carrying his grip-sack and umbrella. He had been far from the scene of the accident and did not even know there had been one. He stood amazed at Josephine's piercing cry at Richards' quick motion to screen him from the view of his wife.
When the doctors came they said she had died of heart disease--of the joy that kills.

Questions

1. Why is Richard anxious about Mrs. Mallard’s probable response to the news of her husband’s death? What is her first reaction to the news of the death? How does this response change as she sits in the chair and looks out of the

window? And finally what is her response to the knowledge that her husband is not dead?

2. Comment on the irony of the last line in which the (male) doctors diagnose her death as resulting from joy while the reader knows that she dies from the shock of realizing that her husband's continued presence in her life will mean a loss of her newfound freedom.
3. In what ways does Kate Chopin make us analyze society's view of the crucial importance of marriage for a woman? 'What could love the unsolved mystery count for in the face of this possession of self-assertion which she suddenly recognized as the strongest impulse of her being!' In what ways does this comment question the central place of romantic love? What does she think is more important than love?
4. This powerful short story asks us to change our assumption that love and marriage are the most important events in the lives of women. The story goes against the way in which mainstream media and pop culture shapes our thinking about this issue through movies advertisements songs and the marketing of romance. How important is it to analyze those ideas that seem 'natural' to us and to question where these ideas come from?

Application

Write a dialogue between Mr. and Mrs. Mallard in which they discuss their relationship. How would Mrs. Mallard try to explain to her husband why she does not feel free in her marriage to him? What would Mr. Mallard say in response? What would be the result of this dialogue? What strategies might Mrs. Mallard use to try to convince Mr. Mallard of her position? Would Mr. Mallard react with anger or with compassion or would he be unable to understand his wife's position altogether?

SKILL ENHANCEMENT COURSES (SEC)

PAPER S1: ANALYTICAL READING AND WRITING

Course Objectives

This course will teach students the fundamentals of rhetorical or persuasive writing organized according to a pedagogic system of academic writing that is followed the world over. Students everywhere are expected to follow this system in universities while they write assignments and take term examinations. In this age of globalized academics Indian students need to know both the theory and practice of academic analysis and academic writing in order for them to participate in an increasingly international academic environment. All of us who teach analysis and writing have learned and internalized this pedagogic structure usually without being consciously aware of its mechanics. In our M. Phil courses we learnt through trial error emulation and example how to write research papers. Those of us who have written Ph. D. theses are aware that we had to write within strict academic norms. Likewise when we read essays that students have written we expect the same academic form of writing from them and penalize them or reward them for their accomplishment in this discipline of writing. But so far nowhere across Indian universities have we seen a systematized codification of such norms in the form of courses or workshops. This course is an attempt to fill this academic gap.

As the title of the course suggests we focus on both reading (which is comprehending and analyzing other writers' rhetorical arguments) and writing (which is producing cogent and complex rhetorical arguments of our own. We want to pass on a uniform set of writing strategies to our students. Students will learn according to the classical principles of rhetoric.

Learning Outcomes

At the end of this course we expect the students to learn the following:

- Consider the act of writing as a goal oriented task oriented towards the goal of persuasion.
- Examine and interpret other writers' writings (contained in the course reader) as a crucial preliminary stage to being able to produce successfully persuasive writing themselves.
- Identify the writer's central purpose or thesis.
- Consider how writers use personal authority and trustworthiness argumentative logic comparison and contrast example and emotional appeals to make their arguments.
- Identify their own historical social and personal contexts to understand their own biases and ideologies.
- Analyse an academic topic or question to gather information and to notionally organize that material required to address that topic or to answer that question.
- Design and then write a lucid thesis statement that outlines the students' central argument in the paper thesis essay or article.
- Produce both preliminary and fleshed-out outlines which identifies the structure of the proposed paper.
- Finally produce a paper that follows the guidelines of their own outline.
- Use the appeals of ethos logos and pathos throughout the paper as multiple persuasive strategies.

Course Contents

Unit 1
How to read/write/think: Rhetoric or the art of persuasion.

Rhetorical Triangle: Consider each writing task as an act of rhetoric—that is an act where someone is communicating to someone else on a subject that is known to both. Imagine a rhetorical triangle made up of a speaker (the writer) the subject (the answer/tute/presentation) and the audience (the teacher/examiner). It is the interaction of the three that makes the act of writing rhetorical in nature. The relationship between writer and audience is unequal in the sense that the writer needs to prove something to an audience who must be assumed to be skeptical and in need of persuasion. To be able to write articulately it is first crucial to read and think with clarity. Each of the three components therefore need to be studied in detail.

a. Writer/Speaker – In the act of writing the writer or the speaker is the student in this class. Therefore the first task is to locate the students in their historical socio-economic cultural materiality. Antonio Gramsci's idea of creating a personal inventory of historical traces to date on the self would be one useful way to think about this.

b. Text – What is a text? From what perspective do we read a text? What is the perspective from which it is written? What is the context in which this argument was made? What is the context in which we are reading it. One of the ways of thinking about these issues to is consider everything around us as a text. We read the world around us all the time. Reading means critically analyzing through prism of one's own ideology. As we read and analyze we evaluate and also form value judgments about them.

c. Audience – We only ever speak/write to persuade an audience. Who are we writing to? With what motive? What investment? Eagleton points out that we only speak if there is reason a motive a message. To analyze the appeals that are used in persuading the audience one first needs to understand the character of the audience.

Unit 2
How to write: Creating a rhetorical argument: What How Why (Definition Evaluation Proposal)

Writing is a goal-oriented task. It is the teaching of each specific rhetorical tool that will form the stages of this course. The syllabus is structured to teach – how to analyze questions how to make thesis statements outlines and paragraphs how to link ideas how to write introductions and conclusions and how to use examples and critics. These skills are to be taught not for their own sakes or to fulfill some aesthetic desire to see a nicely written essay. These skills areinextricable from the rhetoric act of persuasion itself and persuasive witing cannot take place until these skills are systematically learnt.

Thesis Statement

How do we recognize a thesis statement? It answers the question – What are you going to prove? What do you want your reader to believe by the end of your answer? While planning the thesis statement it is important to spell out precisely what you're going to say. It should answer how and why the argument is being written.

Unit 3
How to write: Creating a rhetorical argument: What How Why (Definition Evaluation Proposal)

Outline

The thesis statement discussed earlier outlines the major sections of the essay. The technique of writing the thesis statement is sometimes called *blueprinting*. Based on the thesis statement the formal outline provides a clearer blueprint of the assignment.

Expanding the Outline

In this step the information required under each point in the rough outline needs to be sourced and noted. The evidence needed to support the thesis statement and the authority or analysis of the evidence will flesh out the outline made in the above section.

Unit 4
How to write: Creating a rhetorical argument.

Introduction and Conclusion

There is a format or structure for writing the introduction and the conclusion that is generic to all tasks of writing. These two paragraphs are to be written after the argument has been established and proven to aid the rhetorical task of persuasion.

Unit 5
How to write: Creating a rhetorical argument.

Linkages Transitions and Signposting

These elements are crucial for the writer to lead the reader through the process of following the thesis the outline the evidence and the progression of the argument.

Paragraphing and Sentence Structure

These skills are not taught for their aesthetics. They are crucial to the logical argument as language determines order at the sentence level and the ordering of points in paragraphs determines the structure of the argument.

Readings

There will be a Reader with 8 – 12 texts/readings which will be selected according to graded difficulty to be accessible by students of different abilities. Each reading will be accompanied by a series of topics of discussion to aid reading the text from the different aspects taught in the class. They will also be accompanied by a series of 6 – 10 questions from which one or two questions can be chosen to ask the class to write assignments. The texts would try to cover different issues of interest to students to generate meaningful discussion in class and analysis in the process of writing.

Course structure

The course will be structured around 3 assignments. In the first assignment the student will be expected to analyze the reading and the question and to write about the issues the question asks for and then to condense that into a roughly three sentence thesis statement. The second assignment will require the student to write a thesis statement and to make an outline to match the thesis statement. The third assignment will require the student to start with the thesis statement follow with outline and finally produce an entire essay.

Prose:
1. Jane Tomkins: 'Indians' Textualism Morality and the Problem of History (Difficult)
2. Paulo Friere: 'The ‘Banking’ Concept of Education' (Medium Difficult)
3.Martin Luther King Jr: Letter from Birmingham Jail (Medium medium)
4. Rebecca Solnit: 'Men Explain Things to Me' (Medium Easy)
5. Aurangzeb Letter to his Teacher (Easy)

Poetry
1. Agha Shahid Ali: 'Ghazal' (Difficult)
2. Margaret Atwood: 'This is a photograph of me' (Medium Difficult)
3. Dylan Thomas: 'Do not go gentle into the night (Medium medium)
4. Bob Dylan: 'The Times They are A-changing' (Medium easy)
5. Robert Frost: The Road Not Taken (Easy)

Short Story
1. Heinreich Boll: Stranger Bear word to the Spartans we... Difficult)
2. Shirley Jackson: 'The Lottery' (Medium Medium)
3. Vaikom Basheer: 'The Card-Sharper's Daughter (Medium Medium)
4. Om Prakash Valmiki: 'Joothan' (Easy)
5. Alice Munro

Teaching Plan
Paper S1 – Analytical Reading and Writing

Weeks 1 & 2 -- How to read
Week 3 -- Introduce and Discuss Reading 1
Week 4 -- Thesis Statement

Assignment 1 due Week 5 -- Three paragraphs for thesis statement reduced to three sentences

Week 5 -- Introduce and Discuss Reading 2
Week 6 -- Thesis Statement
Week 7 & 8 -- Outline corresponding to Thesis statement
Assignment 2 due Week 9
Week 9 -- Introduce Reading 3
Week 10 -- Thesis Statement
Week 11 -- Outline
Week 12 -- Introduction and Conclusion
Week 13 -- Rough draft and revision of draft
Week 14-- Assignment 3 due Week 14

Facilitating the achievement of Course Learning Outcomes

Paper S1: ANALYTICAL READING AND WRITING

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts of skill to be taught	Interactive discussions with students to guide them towards skill based learning	Reading theoretical material together in small groups working in peer groups to discuss material
2.	Application of skill	Practical application of skill performed under supervision of teacher	Producing assignments preparing project folders
3.	Demonstrating conceptual understanding and practical application of skill in tests and examinations	Discussing exam questions and answering techniques	Class tests

Keywords

Reading analytically
Reading techniques
Audience
Persuasive writing
Argumentation
The appeals

Logical argument
Authority
Rhetoric
Thesis
Outline
Writing introduction
Writing conclusion
Signposting
Transitions

Sub-committee

Roopa Dhawan Ramjas College (Coordinator)
Vinita Chandra Ramjas College
Rina Ramdev Sri Venkateswara College
Sanam Khanna, Kamala Nehru College

PAPER S2: LITERATURE IN SOCIAL SPACES

Course Objectives

According to Emile Durkheim the categories of time space class personality (and so on) are social in nature. Social spaces therefore have to be understood as products of the distribution of individuals/communities kinship ties and professional relationships. Since such spaces are crucial for the orientation and growth of individuals ideally they should be constructed by ensuring inclusivity empathy and self-awareness.

Humanities as a field encourages us to ask pertinent questions share different world-views and produce alternate truths in the process. It is in this regard that we are offering a course that will use texts (literary or otherwise) to equip students with skills crucial to understand and deal with the practicalities of the everyday be it with regard to workplace intimate networks or social media.Recent research has inferred that the study of Humanities and Social Sciences are effective in developing soft skills considered of vital importance in the dynamic workplace of the 21st Century.

This course draws attention to the link between critical thinking skills developed by studying the Humanities especially Literature and other skills which are often termed ‘soft skills’. The course focuses on the empathy building capacity of Literature and the application of critical thinking and problem solving skills employed in literary analysis to develop an understanding of the value of literature in social and professional spaces. Literary readings will provide the foundation for developing skills such as better communication and empathy understanding the value of teamwork the need for adaptability and the role of leadership and mentoring.

Learning Outcomes

- Students will be familiarised with the link between the Humanities and 'soft skills'
- They will be encouraged to focus on the value of literature as an empathy-building experience.
- They will learn to apply critical thinking and problem solving skills developed by the study of literature to personal social and professional situations.
- Students will be encouraged to enhance their teamwork skills by working in groups and to understand the processes of leadership and mentoring.
- Students will work on their presentation skills and build on the idea of 'narratives' to better communicate with target audiences.

Readings

NOTE: These readings are suggested readings but no direct questions will be asked from them in the examination. The intention is to initiate discussion on the topics and to explore definitions and characteristics through literature. Hence the teacher is free to alter or add readings which she feels are most suited for the purpose of eliciting student interest and response.

Unit 1
Humanities and Soft skills

a) 'Creative and Arts Graduates have the Soft Skills needed to make them Work-Ready' by Mark Harman in *The Independent* 22 June 2016 (https://www.independent.co.uk/student/career-planning/creative-arts-graduates-soft-skills-graduate-employment-university-subjects-work-ready-a7095311.html)
b) 'Leadership in Literature' by Diane Coutu in *The Harvard Business Review* March 2006 (https://hbr.org/2006/03/leadership-in-literature)
c) 'How Literature informs Notions of Leadership' by Gregory L.Eastwood in *Journal of Leadership Education* Vol 9 Issue 1 2010 (http://journalofleadershiped.org/attachments/article/161/JOLE_9_1_Eastwood.pdf)

Unit 2
Emotional Intelligence Adaptability and Mental Health

a) Daniel Goleman. 'Don't let a bully boss affect your mental health' http://www.danielgoleman.info/dont-let-a-bully-boss-affect-your-mental-health/
b) William Blake 'The Chimney Sweeper' from*Songs of Innocence and Songs of Experience* (both versions - 2 poems)
c) W. Somerset Maugham'The Verger' (short story)

Unit 3
Critical Thinking and Problem Solving

a) 'On the Writers Philosophy of Life' by Jack London in *The Editor* October 1899 (essay)
b) Nicholas Bentley'The Lookout Man' (short story) in S.P. Dhanvel's *English and Soft Skills*
(Delhi: Orient Blackswan 2010).
c) J.K. Rowling. 'The Fringe Benefits of Failure and the Importance of Imagination' (extract from her speech at Harvard 2008) https://news.harvard.edu/gazette/story/2008/06/text-of-j-k-rowling-speech/

Unit 4
Teamwork and Team Management

a) Extract from Mark Twain*Huckleberry Finn* in S.P. Dhanvel's *English and Soft Skills*
(Delhi: Orient Blackswan 2010).
b) 'The Builders' by Henry Wadsworth Longfellow (poem)

Unit 5
Leadership and Mentoring

a) 'If' by Rudyard Kipling (poem)
b) 'Are you my Mentor?' by Sheryl Sandberg in *Lean in: Women Work and the Will to Lead*
(London: Penguin Random House 2015).

Suggested Screenings

1. 2002 Documentary -- *The Tales of the Night Fairies* (teamwork leadership and adaptability)
2. 1993 Film --*What's Eating Gilbert Grape?* (self-awareness family and care)
3. 2000 Film-- *Erin Brockovich* (soft skills and empathy)
4. 2003 Film --*Monalisa Smile* (leadership and mentorship)
5. 2016 Film-*Hidden Figures* (affective leadership and teamwork)
6. 2016 TV Serial --*Black Mirror: Season 3 Nosedive* (mental health and social media)
7. 2007 Film -- *Chak De India* (teamwork leadership mentoring)

Teaching Plan
Paper S2 – Literature in Social Spaces

Week 1 – Introduction to Paper
Week 2 – Unit 1 -- Humanities and Soft skills
Week 3 – Unit 1 (contd)
Week 4 – Unit 1 (contd)
Week 5 – Unit 2 --Emotional Intelligence Adaptability and Mental Health
Week 6 -- Unit 2 (contd)
Week 7 – Unit 3 -- Critical Thinking and Problem Solving
Week 8 – Unit 3 (contd)
Week 9 – Unit 3(contd)
Week 10 – Unit 4 -- Teamwork and Team Management
Week 11 – Unit 4 (contd)
Week 12 – Unit 5 -- Leadership and Mentoring
Week 13 – Unit 5 (contd)
Week 14 – Concluding lectures exam issues etc

Facilitating the Achievement of Course Learning Outcomes
PaperS2: Literature in Social Spaces

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts of skill to be taught	Interactive discussions with students to guide them towards skill based learning	Reading theoretical material together in small groups working in peer groups to discuss material
2.	Application of skill	Practical application of skill performed under supervision of teacher	Producing assignments preparing project folders
3.	Demonstrating conceptual understanding and practical application of skill in tests and examinations	Discussing exam questions and answering techniques	Class tests

Keywords

Committee Members

Brati Biswas, Dyal Singh (E) (Coordinator)
Sanam Khanna, Kamala Nehru College
Manpreet Kaur, Shyama Prasad Mukherjee College
Rajorshi Das, Indraprastha College for Women

PAPER S3: LITERATURE IN CROSS-CULTURAL ENCOUNTERS

Course Objectives

Acknowledging literature's status as an important medium in making sense of the world we live in this paper will enable students to critically view their locatedness within a larger globalized context. By reading texts cross-culturally students will engage with people's experience of caste/class gender race violence and war and nationalities and develop the skills of cross-cultural sensitivity.The paper will give them the vocabulary to engage with experiences of people from varying cultures and backgrounds particularly relevant in contemporary times as these issues continue to be negotiated in the workplace as well as larger society.

Learning Outcomes

- The students will develop skills of textual and cultural analysis
- They will develop insights into and interpretations of complex cultural positions and identities.
- They will pay specific attention to the use of language and choice of form/genre that affects the production and reception of meaning between writers and readers.

Readings

Selections from *The Individual and Society: Essays Stories and Poems* edited by Vinay Sood et al. for The Department of English University of Delhi New Delhi Pearson 2006.

Unit 1
Caste/Class

1. 'Caste Laws' -- Jotirao Phule
2. 'Deliverance' -- Premchand

3. ‘Kallu’ -- IsmatChughtai
4. ‘Bosom Friend’ -- Hira Bansode

Unit 2
Gender

1. ‘Shakespeare’s Sister’ -- Virginia Woolf
2. ‘The Exercise Book’ -- Rabindranath Tagore
3. ‘A Prayer for My Daughter’ -- WB Yeats
4. ‘Marriages Are Made’ -- Eunice de Souza
5. ‘The Reincarnation of Captain Cook’ -- Margaret Atwood

Unit 3
Race

1. ‘Blackout’ -- Roger Mais
2. ‘Telephone Conversation’ – Wole Soyinka
3. ‘Harlem’ -- Langston Hughes
4. ‘Still I Rise’ -- Maya Angelou

Unit 4
Violence and War

1. ‘Dulce et Decorum Est’ -- Wilfred Owen
2. ‘Conscientious Objector’ -- Edna St Vincent Millay
3. ‘Naming of Parts’ – Henry Reed
4. ‘General Your Tank Is a Powerful Vehicle’ – Bertolt Brecht
5. ‘A Chronicle of the Peacocks’ – Intizar Husain
6. ‘Ghosts of Mrs Gandhi’ -- Amitav Ghosh

Unit 5
Living in a Globalized World

1. ‘Toys’ -- Roland Barthes
2. ‘Indian Movie New Jersey’ -- Chitra Banerjee Divakaruni
3. ‘At Lahore Karhai’ – Imtiaz Dharker
4. ‘The Brand Expands’ -- Naomi Klein

(5 sections – 12 poems 11 essays/stories – to be completed in 14 weeks 42 lectures + 14 practicals)

Teaching Plan
Paper S3 -- Literature in Cross-Cultural Encounters

Week 1 – Unit 1:Caste/Class

Week 2 – Unit 1(contd)
Week 3 – Unit 1 (contd)
Week 4 – Unit 2: Gender
Week 5 – Unit 2 (contd)
Week 6 – Unit 2(contd)
Week 7 – Unit 2(contd)
Week 8 – Unit 3:Race
Week 9 – Unit 3 (contd)
Week 10 – Unit 4: Violence and War
Week 11 – Unit 4 (contd)
Week 12 – Unit 5: Living in a Globalized World
Week 13 – Unit 5(contd)
Week 14 – Concluding lectures discussion on exam pattern etc.

Facilitating the achievement of Course Learning Outcomes
PaperS3: Literature in Cross-Cultural Encounters

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts of skill to be taught	Interactive discussions with students to guide them towards skill based learning	Reading theoretical material together in small groups working in peer groups to discuss material
2.	Application of skill	Practical application of skill performed under supervision of teacher	Producing assignments preparing project folders
3.	Demonstrating conceptual understanding and practical application of skill in tests and examinations	Discussing exam questions and answering techniques	Class tests

Keywords

Race
Caste
War

Class
Globalisation
Gender
Violence
Literature
Culture
Cross Cultural Encounters
Critical thinking

Commitee Members

Sanam Khanna, Kamala Nehru College (Coordinator)
Amrita Singh, Kamala Nehru College
Samarth Singhal, Kamala Nehru College
Vinita Chandra, Ramjas College

PAPER S4: ORAL AURAL AND VISUAL RHETORIC

Course Description

This paper is designed to introduce students to theory and practice of rhetorical studies. Rhetoric has meant an art an artifact and a kind of discourse. The aim here is to investigate the art of expression whether with words with musical notes or with lens. It is to treat all cultural artifacts such as oratory music photography as texts which can be read/heard/seen and analyzed and appreciated in class. The paper initiates the students to classical and modern rhetorical theories both in the West and in India in the first unit. In the rest of the units students will learn to closely read any non-literary text become attentive listeners and feel the tone and texture of images.

This course surveys and explores a number of rhetorical traditions from around the world studying sample texts along two axes: firstly *temporal* where texts are read in their original historical contexts secondly *ideational* where texts are read for themes and perspectives.

Learning Outcomes

- Students will be trained in developing their oral/aural/visual senses to appreciate a cultural text while at the same time using a theoretical framework and position to read a text.
- Students will learn to identify and engage with the themes of:

i. Argumentation and persuasion
ii Language and writing
iii. Intention and motivation of the author/orator/painter/musician.

iv. Emotive element in speech and music
v. Performative language

Unit 1
Theory of Rhetoric: Western and Indian

1. Herrick James A. ' An overview of rhetoric' *The History and Theory of Rhetoric: An Introduction* (Routledge 2016)p 1-30
2. Aristotle *On Rhetoric: A Theory of Civic Discourse.* Trans. George A Kennedy. *Book 1 chapter 3 p 46-51.*
3. Perelman *The Idea of Justice and the Problem of Argumentation* ('Act and Person in Argument p 196-208).
4. Bharata *Natyasastra* ed and trans. Manmohan Ghosh (selections Chapter 19 p 344-352).
5. Mccrea Lawrence. ''Resonance' and its Reverberations: Two cultures in Indian epistemology of Aesthetic Meaning' *The Bloomsbury Research Handbook of Indian Aesthetics and the Philosophy of Art.* Ed. Arindam Chakrabarti (London: Bloomsbury 2016) pp 25-42

Unit 2
Oratory

1. Martin Luther King: Messianic Myth
   28th August 1963 'I have a Dream' address at march on Washington for Jobs and Freedom
   https://www.youtube.com/watch?v=3vDWWy4CMhE
   25th March 1965 ' Our God is Marching on!'
   https://www.youtube.com/watch?v=5n5WbNCEeHM

   Reading

   Black Jonathan-Charteris. 'Martin Luther King: Messianic Myth' (chapter 3 pp 58-84) *Politicians and Rhetoric: The Persuasive Power of Metaphor* (Palgrave Macmillan 2005).

2. Susan B Anthony on Women's Right to Vote
   https://www.youtube.com/watch?v=T57dwhJBtts

   Reading

   Katheryn M. Conway 'Woman Suffrage and the History of Rhetoric at the Seven Sisters College 1865-1919 *Reclaiming Rhetorica: Women in the Rhetorical Tradition* ed.Andrea A Lunsford.

3. Nehru Tryst with Destiny speech to the Indian constituent assembly on 14th August 1947.
   https://www.youtube.com/watch?v=AzdVKGdZUpQ

Reading

Black Jonathan-Charteris. ‘Persuasion Legitimacy and Leadership’ (chapter 1 pp 1-26) *Politicians and Rhetoric: The Persuasive Power of Metaphor* (Palgrave Macmillan 2005).

Unit 3
Music

1. Bob Dylan musical piece ‘Blowin’ in the wind’.
   https://www.youtube.com/watch?v=G58XWF6B3AA

Readings and music

1. Brian Vickers ‘Figures of Rhetoric/Figures of Music?’ *Rhetorica ii* (1984) 1-44
Karl Eschman, ‘The Rhetoric of Western Music’ *The Musical Quarterly* vol 7 no 2 (April 1921) pp 157-166.
2. Ol’ Man River in many versions and contexts:
    i. Ol’ Man River by Paul Robeson for the film ‘Showboat’ in 1936.
    ii. The version with altered and more revolutionary lyrics which he sang on stage in the
    1930s.
    iii. Bhupen Hazarika's Assamese version ‘BistirnoParare’
    iv. Bangla ‘BistirnoDupare’
    v. Nepali ‘Bristit Kinarako’ with subtitles
3. Sumangala Damodaran ‘The IPTA Musical Tradition's Repertoire’ *The Radical Impulse: Music in the Tradition of the Indian People's Theatre Association* (New Delhi: Tulika 2017).
The chapter ‘Ol' Man River’ in the book *The Undiscovered Paul Robeson: An Artist's Journey 1898-1939* by Paul Robeson Jr.
4. Hemango Biswas ‘A Glorious Heritage’ *Folkmusic and Folklore: An Anthology.*
Pradip Kumar Sengupta *Foundations of Indian Musicology* (ch 7: ‘Raga and Rasa’ p 99-124).
5. ‘Na to Karvan ki talaash hai’ *Barsaat ki Raat* movie of 1950s.
6. Kumkum Sangari ‘Viraha: A Trajectory in the Nehruvian Era’ in *Poetics and Politics of Sufism and Bhakti in South Asia: Love Loss and Liberation* ed. Kavita Panjabi

Unit 4
Photography
Lady Filmer’s Album

Readings and visuals

1. ‘Photographs fun and flirtations’ Patrizia De Bello *Women’s Albums and Photography in Victorian England: Ladies Mothers and Flirts* (Ashgate 2007).
2. Jyotindra Jain ‘The visual culture of the Indo-British cotton trade’ *Marg: A Magazine of the Arts The Story of Early Indian Advertising* (March-June 2017).
3. 1857 uprising photos - Memorial well at Cawnpore(Kanpur) Kashmiri Gate in Delhi the Residency at Lucknow.
4. Karlekar Malavika. ‘Sites of Past Conflict’ (pp57-62) and ‘The ‘Second Creature’ (pp159-164) *Visual History: Photography in the Popular Imagination* (OUP 2013)
5. Dayanita Singh and Aveek Sen‘House of Love’(short story) *House of Love*(Peabody Museum Press 2010).

Teaching Plan
Paper S4 - Oral Aural and Visual Rhetoric

Week 1 – Unit 1 -- Theory of Rhetoric: Western and Indian
Week 2 – Unit 1(contd)
Week 3 – Unit 1(contd)
Week 4 – Unit 1(contd)
Week 5 – Unit 2 -- Oratory
Week 6 – Unit 2(contd)
Week 7 – Unit 2(contd)
Week 8 – Unit 3 -- Music
Week 9 – Unit 3(contd)
Week 10 – Unit 3 (contd)
Week 11 – Unit 4 -- Photography
Week 12 – Unit 4 (contd)
Week 13 – Unit 4(contd)
Week 14 – Concluding lectures discussion on exam pattern etc.

Facilitating the achievement of Course Learning Outcomes
Paper S4: Oral Aural and Visual Rhetoric

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts of skill to be taught	Interactive discussions with students to guide them towards skill based learning	Reading theoretical material together in small groups working in peer groups to discuss material
2.	Application of skill	Practical application of skill performed	Producing assignments preparing project folders

		under supervision of teacher	
3.	Demonstrating conceptual understanding and practical application of skill in tests and examinations	Discussing exam questions and answering techniques	Class tests

Keywords

Rhetoric
Close Reading
Writing
Oratory
Photography
Music

Course Committee

Nabanita Chakraborty, Hansraj College (Coordinator)
Prachee Dewri, Hansraj College
Amrita Singh, Kamala Nehru College
Brati Biswas, Dyal Singh College-E
Prachee Dewri, HRC

PAPERS5: INTRODUCTION TO CREATIVE WRITING FOR MEDIA

Course Objectives

This course introduces students to the concepts of 'creativity' in general and 'creative writing' in particular. This paper focuses especially on writing for the media ranging from newspapers and magazines to emerging new media forms. After being given a foundation in the theoretical aspects of writing for the media real life examples will provide a practical exposure. This course will encourage students to be active readers and writers who will engage with contemporary issues in a well informed manner. This course will be of interest to those students who wish to pursue creative writing especially those who wish to work in the media.

Learning Outcomes

- This course will introduce students to the idea that creativity is a complex and varied phenomenon which has an important relationship with social change.
- Students will become familiar with ideas about language varieties and the nuances of language usage.
- Students will be introduced to the language and types of media writing across forms and genres.
- This course will encourage students to revise their work critically and inculcate the skills of proofreading.

Course Content

Unit 1

What is Creative Writing?

a) Defining and Measuring Creativity

b) Inspiration and Agency Creativity and Resistance

c) What is Creative Writing? Can it be taught?

d) The importance of Reading

Unit 2

The Art and Craft of Creative Writing

a) Styles and Registers

b) Formal and Informal Usage

c) Language Varieties Language and Gender

d) Disordered Language

e) Word order Tense and Time Grammatical differences

Unit 3

Writing for the Media

a) Introduction to Writing for the Media

b) Print Media

c) Broadcast Media

d) New Media

e) Advertising and Types of Advertisments

Unit 4

Revising Rewriting and Proof Reading (pages 205-208)

a) Revising

b) Rewriting

c) Proof reading and proof-reading marks

Prescribed Text
Creative Writing: A Beginners' Manual by Anjana Neira Dev et al. For The Department of English University of Delhi New Delhi Pearson 2008.

Recommended Additional Resources: *English for Journalists* (vol 2) by Wynford Hicks. Routledge: New York2007.

Suggested Methods of Internal Evaluation: It is recommended that students be asked to prepare a portfolio of original writings which will include any 4 from:
a) Creativity in everyday life
b) An advertisement
c) A news report
d) A review of a film/book/play/restaurant
e) A travel review /page from a travelogue
f) An editorial
g) A blog /vlog entry

Teaching Plan
Paper S5 -- Introduction to Creative Writing for Media

Note: Ample time must be devoted in during practical periods to actual writing and the practice of the theory that is taught in class.
Contemporary real time examples are encouraged.
The student's portfolio must emerge based on classroom work and exercises

Week 1 – Unit 1 -- What is Creative Writing?
Week 2 – Unit 1 (contd)
Week 3 – Unit 1 (contd)
Week 4 – Unit 2 -- The Art and Craft of Creative Writing
Week 5 – Unit 2(contd)
Week 6 – Unit 2(contd)
Week 7 – Unit 2(contd)
Week 8 – Unit 3 -- Writing for the Media
Week 9 – Unit 3(contd)
Week 10 – Unit 3(contd)
Week 11 – Unit 4 -- Revising Rewriting and Proof Reading
Week 12 – Unit 4(contd)
Week 13 – Unit 4(contd)
Week 14 – Concluding lectures exam issues etc.

Facilitating the achievement of Course Learning Outcomes
Paper S5: Introduction to Creative Writing for Media

Unit	Course Learning	Teaching and	Assessment Tasks

No.	Outcomes	Learning Activity	
1.	Understanding concepts of skill to be taught	Interactive discussions with students to guide them towards skill based learning	Reading theoretical material together in small groups working in peer groups to discuss material
2.	Application of skill	Practical application of skill performed under supervision of teacher	Producing assignments preparing project folders
3.	Demonstrating conceptual understanding and practical application of skill in tests and examinations	Discussing exam questions and answering techniques	Class tests

Keywords

Creative writing
Writing for the media
Advertisements
Proof reading
Newspaper reports
Media literacy
Blogs
Vlogs
Reviews
Language for the media

Committee Members

Anuradha Marwah, ZHDC (Coordinator)
Shatarupa Sinha, Gargi College
Sanam Khanna Kamala Nehru College
Amrita Singh Kamala Nehru College

PAPER S6 -- TRANSLATION STUDIES

Course Objectives

In a multicultural country like India translation is necessary for better governance and for greater sensitivity to other cultural groups. As the world shrinks further due to increased communication translation is required for smooth flow of knowledge and information. The course will sensitise students to the processes involved in translation. Students will be familiarised with various methods strategies and theories of translation. Further they will learn to recognise a translated text as a product of its cultural social political and historical contexts.

Learning Outcomes

Through the study of this course the student will develop the ability to

- sensitively translate literary and non-literary texts including official and technical documents from one language to another.
- interpret from one language to another.
- examine what is translated and why
- discern the difference in language systems through the practice of translation.
- understand the processes involved in translation in mass media especially news reporting advertising and films.
- engage with the demands of subtitling and dubbing.
- compare translations.
- evaluate and assess translated texts.
- edit translated texts.

Course Content

Unit 1
Introducing Translation

Introducing a brief history and significance of translation in a multi-linguisticand multicultural society like India.
Introducing basic concepts and terms used in Translation Studies through relevant tasks:
Equivalence Source Language Target Language Source Text Target Text Language variety Dialect Idiolect Register Style Mode Code mixing and Switching transliteration simultaneous and consecutive interpreting.

Unit 2

a. Brief Theory of Linguistics – morphology phonology syntax
b. Defining the process of translation (analysis transference restructuring) through critical examination of diverse translated texts.

Unit 3
Types and modes of translation

a. Semantic and Literal translation
b. Free Sense-to-sense and Literary translation
c. Functional and Communicative translation
d. Technical and Official translation
e. Transcreation
f. Audio-visual translation: subtitling dubbing voice-overs
g. Back translation
h. Rank-bound and Unbounded translation
i. Machine Translation

Unit 4
Practice of Translation

Source Texts
Idiomatic Expressions/ Headlines/Taglines
Poetry
Short-story/Novella/Excerpt from a novel
Newspaper Report/Editorial/Review/Feature Article
Songs/Films
Advertisements: Print and Audio-Visual

Unit 5
Issues in Translation

Translation and Gender
Translation and Caste
Translation and Culture
Translation and Technology
Translation and Mass Communication
Comparison and Evaluation of Translated texts

Suggested Readings

1. Baker Mona *In Other Words: A Coursebook on Translation*. London and New York:
   Routledge 2011.
   (Useful exercises for practical translation and training)
2. __________ ed.*Routledge Encyclopedia of Translation Studies*. London and New York:
   Routledge 2001.

3. Bassnett Susan. *Translation Studies*. 4th Ed. London and New York: Routledge 2014.
4. __________ and Harish Trivedi eds. *Postcolonial Translation: Theory and Practice*. London and New York: Routledge1999.
5. Catford I.C. *A Linguistic Theory of Translation*. London: OUP 1965.
6. Frishberg Nancy J. *Interpreting: An Introduction*. Registry of Interpreters 1990.
7. Gargesh Ravinder and Krishna Kumar Goswami eds.*Translation and Interpreting: Reader and Workbook*. New Delhi: Orient Longman 2007.
8. Hatim Basil and Jeremy Munday. *Translation: An Advanced Resource Book*. London and New York: Routledge 2004.
9. House Juliana. *A Model for Translation Quality Assessment*. Tubingen: Gunter Narr 1977.
10. Lakshmi H. *Problems of Translation.* Hyderabad: Booklings Corporation 1993.
11. Mukherjee Sujit. *Translation as Discovery: And Other Essays on Indian Literature in English Translation.* New Delhi: Allied 1981.
12. Newmark Peter. *A Textbook of Translation.* London: Prentice Hall 1988.
13. Nida E.A. and C.R. Taber. *The Theory and Practice of Translation*. Leiden: E.J. Brill 1974.
14. Niranjana Tejaswini. *Siting Translation: History Post-Structuralism and the Colonial Context.* Hyderabad: Orient Longman 1995. First Published: University of California Press 1992.

Teaching Plan

Paper S6 – Translation Studies

WEEK 1 -- Introduction to Translation Studies
Unit 1 (a): A brief history of translation in India significance of translation in a multilingual and multicultural society like India
Unit 1(b): Introduction to basic terms and concepts used in translation studies through relevant tasks -- Source Language Target Language Source Text Target Text.
WEEK 2 -- Unit 1(b) contd: Language Variety Dialect Idiolect Register Style Equivalence Mode Code Mixing and Switching Transliteration Simultaneous and Consecutive Interpreting.
WEEK 3 --Unit 2 (a) Brief theory of Linguistics – Morphology Phonology Syntax

WEEK 4 -- Unit 2(b) Defining the process of translation (analysis transference restructuring) through critical examination of diverse translated texts.
WEEK 5 -- Unit 3: Discussing types and modes of translation with examples
a. Semantic and Literal translation
b. Free Sense-to-sense and Literary translation
c. Functional and Communicative translation
WEEK 6 -- Unit 3 contd.
d. Technical and Official translation
e. Transcreation
f. Audio-visual translation: subtitling dubbing voice-overs
WEEK 7 -- Unit 3 contd.
g. Back translation
h. Rank-bound and Unbounded translation
i. Machine Translation
WEEK 8 -- Unit 4: Practice of translation with examples
Idiomatic Expressions/ Headlines/Taglines
Newspaper Report/Editorial/Review/Feature Article
WEEK 9 -- Unit 4 contd.
Poetry Songs/Films Advertisements: Print and Audio-Visual
WEEK 10 -- Unit 4 contd.
Short-story Novella Excerpt from a novel
WEEK 11 -- Unit 5: Discussing Issues in Translation
Translation and Gender
Translation and Caste
WEEK 12 -- Unit 5 contd.
Translation and Technology
Translation and Mass Communication
WEEK 13 -- Unit 5 contd.
Translation and Culture
Comparison and Evaluation of Translated Texts
WEEK 14 -- Discussion of individual portfolios

Facilitating the achievement of Course Learning Outcomes
PaperS6-- Translation Studies

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts of skill to be taught	Interactive discussions with students to guide them towards skill based	Reading theoretical material together in small groups working in peer groups to discuss material

		learning	
2.	Application of skill	Practical application of skill performed under supervision of teacher	Producing assignments preparing project folders
3.	Demonstrating conceptual understanding and practical application of skill in tests and examinations	Discussing exam questions and answering techniques	Class tests

Keywords

Translation
Interpreting
Source text
Target text
Source language
Target language
Equivalence
Machine translation
Adaptation
Transcreation

Commitee Members

Anjana Srivastava, Kamala Nehru College (Coordinator)
Neha Khurana, Gargi College
Tasneem Shahnaaz, ARSD
Tulika Prasad, Satyawati College-E

PAPER S7 -- INTRODUCTION TO THEATRE AND PERFORMANCE

Course Objectives

The course is intended for students who specialise in English Literature. The idea is to acquaint them with historical processes at work to understand the way in which techniques/methodology of drama have evolved over a period of time. There are two aspects to this course. One is the development of aesthetics in the Indian context from the pre-independence to post-independence period. The course also looks at censorship acts the politics of the market and other factors to locate the socio-political context of drama. There will also be a discussion of the popular forms of performance in India. The second aspect is the development of theories and practice of drama in Europe and their impact on the Indian context.

Learning Outcomes

- The students opting for this course will be able to understand the different theories of drama in Europe and India both from the point of view of theory and performance.
- The students will be able to make connections between socio-economic processes at work and the emergence of a certain kind of dynamic within theatre.
- As this is a Skill Enhancement Course the students will put up a performance at the end of the course making use of the different kinds of aesthetics they have studied.

Unit 1
Introduction

- What is a text?
- What is a performance?
- The uniqueness of the dramatic text: Literature and/or Performance?
- The politics of a Dramatic text: endorsement status quo vs. subversion

Unit 2
Theories of Performance

- Performance theory
  (Richard Schechner/Dwight Conquergood)
- Radical theories
  (Bertolt Brecht Augusto Boal)
- Classical theories
  (Natyashastra Aristotle)

Unit 3
The State the Market and the History of Theatre

- Under British rule
  (Viceroy Northbrook–censorship *Neeldarpan Nabanna*– IPTA)
- (Popular forms: Jatra Tamasha Nautanki Burrakatha Dastangoi and others)

- Modern Indian theatre in the post-independence period
    - (Bourgeois theatre and theatre of change Feminist theatre)
    - (Street theatre Janam)

Unit 4

Modern Western theatre

- Naturalism (Realism)
    - (Stanislavsky)
- Epic theatre: theatre as criticism
    - Brecht Dario Fo and France Rame)
- Theatre that resists the state and market

Unit 5

The Performative Act

- Performance space
    - (in the round proscenium amphitheatre thrust stage etc.)
- Space Lights Costumes Sets

The students must be asked to create a performance from a text (their choice/assisted by the teacher).

Readings

'Faith and the Sense of Truth' Section I (pp. 121-23)
From chapter 8
Stanislavski Constantin. 1936. *An Actor Prepares*. London: Methuen 1988
'A Short Organum for the Theatre' (para 26 - 67) (pp.186-201)
Brecht Bertolt. *Brecht on Theatre: The Development of an Aesthetic*. Trans. and Ed. Willett John.New York: Hill and Wang 1957.
'Breaking Down the Fourth Wall' (pp. 73-74)
Dario Fo. *The Tricks of the Trade*. Trans. Joe Farell. London: Methuen Drama 1991.
'The Fan and the Web' (pp. xvi -xix)
Schechner Richard.*Performance Theory* New York: Routledge 2002

Suggested Plays for Performance

Euripides *Medea*
Clifford Odet *Waiting For Lefty*
Bertolt Brecht *Caucasian Chalk Circle*
Dario Fo *Can't Pay Won't Pay*
Franca Rame *A Woman Alone*
Mahesh Dattani *Dance Like A Man*

Teaching Plan

Paper S7 -- Introduction to Theatre and Performance

Week 1 – Introduction to Paper 10: Introduction to Text and Performance
Week 2 – Unit 1 – Introduction (contd)
Week 3 – Unit 2 – Theories of Performance
Week 4 – Theories of Performance (contd)
Week 5 – Unit 3 -- The State the Market and the History of Theatre
Week 6 – Unit 3 (contd)
Week 7 – Unit 3 (contd)
Week 8 – Unit 4 --Modern Western theatre
Week 9 – Unit 4 (contd)
Week 10 – Unit 5 -- The Performative Act
Week 11 -- Unit 5 (contd)
Week 12 – Discussion of plays and rehearsals for performance
Week 13 – Discussion of plays and rehearsals for performance
Week 14 – Concluding lectures exam issues etc.

Facilitating the Achievement of Course Learning Outcomes
Paper S7 -- Introduction to Theatre and Performance

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts of skill to be taught	Interactive discussions with students to guide them towards skill based learning	Reading theoretical material together in small groups working in peer groups to discuss material
2.	Application of skill	Practical application of skill performed under supervision of teacher	Producing assignments preparing project folders
3.	Demonstrating conceptual understanding and practical application of skill in tests and examinations	Discussing exam questions and answering techniques	Class tests

Keywords

Performance theory
Natyashastra
Radical drama
Classical theory
Bertolt Brecht
Augusto Boal
Neeldarpan
Nabanna
IPTA
Jatra
Tamasha
Nautanki
Burrakatha
Dastangoi
Street theatre
Janam in the round
Proscenium
Amphitheatre
Thrust stage

Commitee Members

Sanjay Kumar, Hansraj College (Coordinator)
Payal Nagpal, Janki Devi Memorial College
Anshuman Singh, Dyal Singh College
Manpreet Kaur, Shyama Prasad Mukherjee College

PAPER S8: MODES OF CREATIVE WRITING -- POETRY FICTION AND DRAMA

Course Objectives

This course introduces students to Creative Writing in the three fundamental modes – poetry fiction (short story and novel) and drama (including scripts and screen plays). The students will be introduced to the main tropes and figures of speech that distinguish the creative from other forms of writing. The students will be able to see language as not just a means of communication but as something that can be played with and used for the expression of the whole range o f human emotion and experiences. Within each literary mode the students will study conventional as well as contemporary expressions. This course will interest those who wish to engage with the discipline of creative writing in its varied manifestations.

Learning Outcomes

- This course will introduce students to a variety of tropes and figures of speech and sensitise them to the texture of literary language. This will help them to understand the importance of reading with a view to unlocking the writers' craft.
- The students will be introduced to the various forms of poetry fiction and drama and the wide range of possible genres within them.
- The students will be made aware of the range of career opportunities that exist within the field of creative writing as well as within the realm of theatre and performance.
- This course will encourage students to revise their work critically and inculcate the skills of editing and preparing their work for publication.

Course Contents

Unit 1
The Art and Craft of Writing

a) Tropes and Figures of Speech
(examples of figures of speech based on similarity/obliqueness/difference/extension/utterance and word building should be discussed and practiced in class)

Unit 2
Modes of Creative Writing -- Poetry and Fiction

a) Writing to Communicate
b) Writing Poetry-Definitions of Poetry/Difference between Poetry and Prose
c) Form and Technique Shapes
d) Dominant Forms and Modes of Poetry
e) Writing Verse for children
f) Writing Fiction-Differences between Fiction and Non Fiction
g) Literary and Popular Fiction
h) Creating Character Plot Setting and POV
i) Writing for Children

Unit 3
Modes of Creative Writing-Drama and Screenplay

a) What is a Drama-Concept
b) Plot and Character in Drama
c) Verbal and Non-verbal elements in Drama
d) Contemporary Theatre in India – a brief overview

e) Writing for Films --Screenplay conventions
f) Scripting for Children --Theatre and Films

Unit 4
Editing and Preparing for Publication (pages 208-216)

a) Editing and proof reading your manuscript
b) Preparing a manuscript for Publication

Prescribed Text
Creative Writing: A Beginners' Manual by Anjana Neira Dev et al. for The Department of English University of Delhi New Delhi Pearson 2008.

Recommended Additional Resources
Cambridge Companion to Creative Writing edited by David Morley and Philip Nielsen.
Cambridge University Press: Cambridge 2012.

Suggested Methods of Internal Evaluation

It is recommended that students be asked to prepare a portfolio of original writings which will include any 4 from:
a) Illustrated examples using tropes and figures of speech in writing
b) A Poem
c) A Short Story
d) A Dramatic Sequence
e) Writing for Children -- a poem/short story/dramatic sequence
f) A Dummy Manuscript
g) A poem/short story/dramatic sequence in a different form from the one used in a)/b)/c)

Teaching Plan
Paper S8: Modes of Creative Writing -- Poetry Fiction and Drama

Note: Ample time must be devoted in during practical periods to actual writing and the practice of the theory which is taught in class.
Students should be encouraged to engage with texts and can suggest texts which they have an interest in
The student's portfolio must emerge based on classroom work and exercises

Week 1 – Unit 1--The Art and Craft of Writing
Week 2 –Unit 1: continued

Week 3 – Unit 1: continued
Week 4 – Unit 2-- Modes of Creative Writing -- Poetry and Fiction
Week 5 –Unit 2: continued
Week 6 – Unit 2: continued
Week 7 – Unit 2: continued
Week 8 – Unit 3--Modes of Creative Writing -- Drama and Screenplay
Week 9 – Unit 3: continued
Week 10 – Unit 3: continued
Week 11 – Unit 3: continued
Week 12 – Unit 4: Editing and Preparing for Publication
Week 13 – Unit 4: continued
Week 14 – Concluding lectures discussion on exam pattern etc.

Facilitating the Achievement of Course Learning Outcomes
Paper S8: Modes of Creative Writing: Poetry Fiction and Drama

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts of skill to be taught	Interactive discussions with students to guide them towards skill based learning	Reading theoretical material together in small groups working in peer groups to discuss material
2.	Application of skill	Practical application of skill performed under supervision of teacher	Producing assignments preparing project folders
3.	Demonstrating conceptual understanding and practical application of skill in tests and examinations	Discussing exam questions and answering techniques	Class tests

Keywords

Creative writing
Writing fiction
Writing poetry

Writing for children
Writing for the stage
Script writing
Writing for theatre

Committee Members

Anjana Neira Dev, Gargi College (Coordinator)
Sanam Khanna, Kamala Nehru College
Amrita Singh, Kamala Nehru College
Anuradha Marwah, ZHDC

PAPER S9: ENGLISH LANGUAGE TEACHING

This course is designed to help students of the undergraduate program develop pedagogical and theoretical skills required for teaching English language. Other than basic theories in ELT it will examine a variety of aspects related to learner needs including multiple intelligences learning styles and strategies communication strategies classroom management issues use of technology and concepts of learner autonomy and learner training. The course will also explore important aspects of learning teaching and assessment for English language as well as certain fundamental aspects of the same.

Course Objectives

- to recognize the role of affect in language learning and account for individual differences among learners in regard to motivation and attitude personality factors and cognitive styles
- to help identify and adapt to the needs and expectations of the learner
- to be aware of the significant and current approaches in the fields of cognition and language pedagogy
- to highlight the importance of teaching materials (in relation to the teaching-learning context and their teaching purposes)
- to understand the importance of planning in ELT and develop lessons in the framework of a planned strategy adapted to learners' level.
- to strengthen concepts of the fundamentals of English language.
- to understand the need for assessment and devise techniques for an evaluation plan that is integrated into the learning process.

Course Content

Unit 1

English Language Teaching

1. Knowing the Learner
2. Learner Variables – age gender learning and participation styles learning disabilities multiple intelligences socioeconomic & cultural background motivation levels of proficiency
3. Theories of Learning – Bloom’s taxonomy Krashen’s concept of Comprehensible Input Vygotsky’s Zone of Proximal Development (Vygotsky could be deleted)
4. Modern Approaches to teaching -- Communicative Language Teaching Task based Approach Cooperative Learning Dogme approach (materials-light teaching) and Bring your own device (Mobile learning).

Unit 2
Structures of English Language:

1. Phonetics – speech mechanisms (vowels and consonants) features of connected speech – word stress rhythm intonation
2. Morphology – word formation processes (coining borrowing etc.)
3. Syntax – parts of speech clauses & phrases punctuation

Unit 3
Teaching Language: Methods Practices and Materials

i. Lesson Planning: lesson aim and objectives context for practice skill focus board work.
ii. Teaching listening skills
iii. Teaching speaking skills
iv. Teaching reading skills
v. Teaching vocabulary
vi. Teaching writing skills
vii. Teaching grammar

Unit 5
Assessing language skills

i. Addressing errors and language expectations (desired level of proficiency)
ii. Qualities of a good test – transparency validity reliability wash back effect
iii. Types of assessment – formal versus informal summative versus formative large scale versus classroom

Suggested Readings

1. Penny Ur. *A Course in Language Teaching: Practice and Theory* (Cambridge: CUP 1996).
2. Marianne Celce-Murcia Donna M. Brinton and Marguerite Ann Snow. *Teaching English as a Second or Foreign Language* (Delhi: Cengage Learning 4th edn 2014).
3. Adrian Doff (1988) *Teach English: A Training Course For Teachers (Teacher's Workbook).* Cambridge: CUP.
4. Harmer J. (2007) *How to teach English* (new ed.). Harlow Essex England: Pearson Longman.
5. Krashen Stephen D. (1985) *The Input Hypothesis: Issues and Implications.* London: Longman.
6. Lee Icy. (2017) *Classroom Writing Assessment and Feedback in L2 School Contexts*. Hong Kong: Springer.
7. Lightbown and Spada (2006) 'Corrective feedback in the classroom' in *How languages are learned* (third edition). Oxford: Oxford University Press 125-28.

8. Aslam Mohammad. (2009) *Teaching of English.* 2nd edn. New Delhi: CUP.
9. Nunan D. Ed. (2003) *Practical English Language Teaching*. New York: McGraw Hill.
10. Littlewood W. (1981) *Communicative Language Teaching: An Introduction*. Cambridge: CUP.
11. Woodward T. (2012) *Planning Lessons and Courses*. Cambridge: CUP.
12. Rivers W. (2000) *Interactive Language Teaching*. Oxford: OUP.

Teaching Plan
Paper S9 -- English Language Teaching

Week 1 -- Introduction to ELT
Week 2 -- Knowing the variables regarding the learner
Week 3 -- Learning theories
Week 4 -- Modern Approaches to teaching
Week 5 -- Phonetics morphology and Syntax
Week 6 -- Lesson Plan
Week 7&8 -- Teaching Listening Speaking Reading Writing Skills
Week 9 -- Teaching Vocabulary and Grammar
Week 10 -- Assessing proficiency
Week 11 -- Knowing the Qualities of a good test
Week 12 & 13 -- Knowing the different kinds of test
Week 14 -- Preparing a lesson plan and a test of proficiency

Facilitating the achievement of Course Learning Outcomes
Sec 9: English Language Teaching

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts of skill to be taught	Interactive discussions with students to guide them towards skill based learning	Reading theoretical material together in small groups working in peer groups to discuss material
2.	Application of skill	Practical application of skill performed under supervision of teacher	Producing assignments preparing project folders

3.	Demonstrating conceptual understanding and practical application of skill in tests and examinations	Discussing exam questions and answering techniques	Class tests

Keywords

Pedagogical skills
Learner needs
Learner autonomy
Assessment
Teaching plan
Phonetics
Listening
Good test
Teaching plan
Communicative skills
Reading skills
Writing skills
Speaking and listening

Course Committee

Tasneem Shahnaaz, ARSD
Anjana Srivastava, Kamala Nehru College
Sanam Khanna, Kamala Nehru College
Tulika Prasad, Satyawati College-E

PAPER S10: FILM STUDIES

Course Objectives

This paper enables students to gain skills in the language of film via appreciation of its specific features as a medium. The course is practically oriented so as to encourage students to acquire the competence necessary to become engaged viewers critics/reviewers and creators/producers in the medium. The course will attempt to make film a democratic and accessible medium for students as creative and analytical persons and may further enable students to take up work in different arenas of digital humanities.

Learning Outcomes

1. To examine those specific features of composition that help create films: camera- sound- script- and editing-work will be studied so that students learn the elements of putting a film together.
2. To study cinema as a form with history and context the paper traces genres and geographies examining the legacies left to us to renew.
3. To take up work in the medium the course will require them to write and review films so as to generate a repertoire of analyses and interpretations.
4. Projects and/or practical work may be used to supplement units 1&4 most particularly to help students interested in the medium to build up a portfolio of work through practice of the Discipline.

Course Content

Unit 1
Language of Cinema

Mise en scene - cinematography - editing - sound

Reading
Dix Andrew. *Beginning Film Studies*. Pp. 9-100. New Delhi: Viva 2010.

Unit 2
Genre in Hollywood Cinema

Definitions of genre -- taxonomies of genre -- genre as economic strategy -- genre as cognition -- rethinking genre

Reading
Nelmes Jill Ed. *An Introduction to Film Studies*. Pp. 152-169. London and New York: Routledge 2003.

Unit 3
Themes from Contemporary Indian Cinema (From the 70s to the present)

The city -- underworld -- communalism -- terrorism -- gender issues -- the Indian Art Cinema

Readings
a) Mazumdar Ranjani. *Bombay Cinema: An Archive of the City*. Pp. 79-109. Ranikhet: Permanent Black 2007.

b) Vasudevan Ravi. '*The Melodramatic Public*'. Pp. 303-333. Ranikhet: Permanent Black 2010.

Unit 4
Film Review Criticism and Script writing

Readings
A Short Guide to Writing About Film (9th Ed) Timothy Corrigan.Pearson 2014.

Screenplays
a) Vishal Bhardwaj *Maqbool*
b) *Thelma and Louise*

Suggested Films
a) *Psycho* (1960 dir. Alfred Hitchcock)
b)*Jaane Bhi Do Yaaro* (1983 Kundan Shah)
c) *Akam* (2013 dir. Shalini Usha Nair)
d) *Nayakan* (1987 dir. Mani Ratnam) - Tamil
e) *Hirak Rajar Deshe* (1980 dir. Satyajit Ray) - Bangla

Suggested Readings

a) Mrinal Sen and Arun Kaul 'Manifesto of the New Cinema Movement' in Scott Mackenzie (Ed.) *Film Manifestos and Global Cinema Cultures: A Critical Anthology*. Pp. 165 -168. Berkeley London and Los Angeles: University of California Press 2014.
b) Rajadhyaksha Ashish. 'The 'Bollywoodization of the Indian Cinema: Cultural Nationalism in a Global Arena' in Anandam P. Kavoori and AswimPunathambekar (Ed.) *Global Bollywood*. Pp. 17-40. New Delhi: OUP 2009.

Unit 5
Practical Component Evaluation

1. Students may turn in a portfolio of 4 film reviews/one academic paper/one short film/one film script (fiction or nonfiction)
2. For reviews: criteria for choice of films must be explicitly stated in the form of a position paper. Films must be from a wide time-arc and must include old and just-released films. Total word count of 4 reviews+position paper must not exceed 3000 words.
3.Academic paper can be on any aspect of film and follow all the usual considerations thereon. 3000 words including bibliography and notes.
4. Film script including shots camera position sound/background notes and cuts. Script may be for a film of max 20 minutes length.
5. Film Length: 5-7 minutes of moving image not stills. Films can be evaluated as creative output on the following counts and teachers may decide what gets weightage

for the entries they receive: Creativity Originality Screenplay/ Storytelling Technical Execution Narrative/ Performance/Props costumes sets locations (production design) Cinematography (camera angles movement lighting frames etc.) Use of background music/enhancement w credit - Use of visual enhancements like transitions titles credits subtitles or even special effects etc...if any

Teaching Plan
Paper S10 – Film Studies

Week 1 – Unit 1 - Language of Cinema
Mise en scene - cinematography - editing - sound
Readings: Dix Andrew. *Beginning Film Studies*. Pp. 9-100. New Delhi: Viva 2010.
Week 2 – Unit 1 (contd.)
Week 3 – Unit 1 (contd.)
Week 4 –Unit 1 (contd.)
Week 5 --Unit 2 -- Genre in Hollywood Cinema. Definitions of genre -- taxonomies of genre –
genre as economic strategy -- genre as cognition – rethinking genre
Readings: Nelmes Jill Ed. *An Introduction to Film Studies*. Pp. 152-169. London and New York: Routledge 2003.
Week 6 – Unit 2 (contd.)
Week 7 – Unit 2 (contd.)
Week 8 – Unit 3 -- Themes from Contemporary Indian Cinema. From the 70s to the present city -- underworld -- communalism -- terrorism -- gender issues -- the Indian Art Cinema
Readings
a) Mazumdar Ranjani. *Bombay Cinema: An Archive of the City*. Pp. 79-109. Ranikhet:Permanent Black 2007.
b) Vasudevan Ravi. 'The Melodramatic Public'. Pp. 303-333. Ranikhet: Permanent Black 2010.
Week 9 – Unit 3 – (contd.)
Week 10 -- Unit 3 – (contd.)
Week 11 –Unit 4 -- Film Review Criticism and Script writing
Readings: *How to write about film* by Timothy Corrigan.
Week 12 – Unit 4 (contd.)
Week 13 – Unit 4 (contd.)
Week 14 – Unit 4 (contd.)

Facilitating the Achievement of Course Learning Outcomes
SEC 10: Film Studies

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts of skill to be taught	Interactive discussions with students to guide them towards skill based learning	Reading theoretical material together in small groups working in peer groups to discuss material
2.	Application of skill	Practical application of skill performed under supervision of teacher	Producing assignments preparing project folders
3.	Demonstrating conceptual understanding and practical application of skill in tests and examinations	Discussing exam questions and answering techniques	Class tests

Keywords

Language of Cinema
Genre
Hollywood Cinema
Contemporary Indian Cinema
Indian Art Cinema
Film Review
Criticism
Script Writing

Course Committee

Namita Paul, Kamala Nehru College (Coordinator)
Nidhi Bhandari Kamala Nehru College
Sachin N, Dyal Singh Colleg
Sakshi Dogra, Hansraj College
Shweta Sachdeva Jha, Miranda House
Vinod Verma, Maharaja Agrasen College

PAPERS11: APPLIED GENDER STUDIES: MEDIA LITERACIES

Course Objectives

This course will help students perceive understand and interpret issues of gender in various cultural texts in India particularly in mass media representations including advertising cinema and journalism. The course aims to mainstream ideas from gender theory so as to equip the common student to intervene in these issues in an informed way and to become both an informed consumer as well as a confident and ethical participant. The course will focus on enhancing students' textual skills via the use of Indian primary conceptual critical and applied texts to create media literacy.

Learning Outcomes

- Train students to identify read closely and rewrite narratives of gendered privilege in contemporary Indian popular representation.
- Examine the intersections of gender with other categories like caste race etc. to understand how different forms of privilege/oppression and resistance/subversion interact in heterogeneous and variable formations.
- Focused on practical application students will over the duration of the course create a portfolio of interpretative work that analyses fictional and non-fictional mass medium narratives and that can serve as foundations/sourcebooks for intervention to reduce gender discrimination through media literacy.
- The course may be taught to Honours and Program course students. Teachers may evolve more advanced practical work methodologies for advanced students.

Course Content

Unit 1
Gender/s: concepts and frameworks

Femininities/Masculinities Cis/Trans bodies Heterosexuality/ Homosexuality/
Heteronormativity/ Heteropatriarchy Sexism/Privilege/Biology/Reproduction

Unit 2
Analysing gender in advertising

The use of gendered stereotypes and privilege in advertising hegemonic and normative ideas of gender and sexuality in selling and buying products consumption of goods bodies
commodification and objectification the reach and memorability of advertising
matrimonial and personal ads and reinforcement of caste/class/gender binaries.

Unit 3
Analysing representations of gender in reporting and journalism

Vocabulary of news media coverage in relation to gender representation of masculine/feminine/non-dimorphic bodies Re-narrativizing this vocabulary productively difference in coverage of stories of obviously 'gendered' subjects such as rape heroism war domestic violence sexual harassment and supposedly 'neutral' subjects like labour rights or work and wages or health or politics advocacy networks for various minority subjects persistence of sexism in new media

Unit 4
Gender as represented in film (fiction and nonfiction/documentary)

Narrative time available to male/female/trans subjects use of normative heterosexuality and gender privilege in plots casting narrative development and marketing of films the Bechdel test: the importance of clearing it and the implications for mainstream narrativization consistently failing the test documentary films for presentation of alternative narratives.

Readings

1.Kandasamy, Meena. 'Screwtiny' 'Pride goes before a full-length mirror' 'Joiussance' and 'Backstreet Girls' in *Ms Militancy*. Delhi: Navayana 2014.
2. Dasgupta, R.K and Gokulsing K. M. 'Introduction: Perceptions of Masculinity and Challenges to the Indian Male' Rohit K. Dasgupta & K. Moti Gokulsing (eds). *Masculinity and its Challenges in India: Essays on Changing Perceptions*. Jefferson NC: McFarland 2014 pp 5-26
3.Selections from *Autobiographies of Transgenders*: Laxmi PG Joshi (translator) and R Raj Rao (translator) *Me Hijra Me Laxmi*.New Delhi: OUP/ A. Revathi V. Geetha. *The Truth About Me: A Hijra Life Story*. New Delhi: Penguin 2010.
4.Nadimpally S. and V. Marwah.'Shake her she is like the tree that grows money! In *Of Mothers and Others: Stories Essays Poems*.' Edited by J. Mishra. New Delhi: Zubaan 2013.
5. Chaudhuri Maitrayee. 'Gender and Advertisements: The Rhetoric of Globalisation' *Women's Studies International Forum* 2001 24.3/4 pp. 373-385.
6. Jha Sonora and Mara Adelman. 'Looking for love in all the white places: a study of skin color preferences on Indian matrimonial and mate-seeking websites.' *Studies in South Asian Film & Media* 1.1 (2009): 65-83.
7. View and discuss *any one* of the feature films: (a) *Dangal* (Dir. Nitish Tiwari. 2016. UTV and Walt Disney Pictures) (b) *Chak De* (Dir. Shimit Amin. Yash Raj Films 2007) (c) *Pink* (Dir. Aniruddha Roy Chowdhury. Rashmi Sharma Telefilms 2016).
8. View and discuss the documentary films *Unlimited Girls* (Dir. Paromita Vohra. Sakshi 2002) and *Newborns* (Dir. Megha Ramaswamy. Recyclewala Labs 2014).

9. *Khabar Lahariya*FAQ (http://khabarlahariya.org/faqs/ accessed on 05.05.2018) and 'Open letter to ourle Colleagues of the Media World from Khabar Lahariya Editors' (http://khabarlahariya.org/an-open-letter-to-our-male-colleagues-of-the-media-world-from-khabar-lahariya-editors/ May 03. 2018. Accessed on 05.05.2018).
10. Rege Sharmila 'Dalit Women Talk Differently: A Critique of 'Difference' and Towards a Dalit Feminist Standpoint Position' in *Economic and Political Weekly* Vol. 33 No. 44 1998 pp. WS39-WS46.
10. Dixit Neha and Sen Orijit. 'The Girl Not from Madras.' In *First Hand*. Delhi: Yoda Press 2016. Pp 324-43 and 'It is Hard to be a Journalist in India. Is it Harder if you're a Woman?' (http://theladiesfinger.com/press-freedom/ September 16 2016. Accessed on 05.05.2018).
12. Siddiqui Gohar. 'Behind Her Laughter is Fear: Domestic violence and transnational feminism'. *Jump Cut* 55 (2013 Fall) (https://www.ejumpcut.org/archive/jc55.2013/SiddiquiDomesAbuseIndia/index.html. accessed on 05.05.2018)

Notes
For visually challenged students

Reading no. 7 is Phadke Shilpa Sameera Khan and Shilpa Ranade. 'Why Loiter? Women and Risk on Mumbai Streets'. New Delhi: Penguin 2011. Pp. 65—106.
Reading no. 8 is Agnihotri Anita. 'The Peacock.'*Seventeen*. New Delhi: Zubaan 2011. 69-79 and Paromita Vohra's 'Interview with Veena Mazumdar part 1' and 'Interview with Veena Mazumdar part 2'. Unlimited Girls footage. Point of View. https://pad.ma/MH/info and (https://pad.ma/NC/info. Accessed on 05.05.2018).
Reading 10 to replace graphic story is 'Sarpanch Woodcutter Handpump Mechanic: Dalit Women in UP tell Women@Work Stories'. (http://theladiesfinger.com/woodcutter-sarpanch-handpump-mechanic-dalit-women-work-stories. May 02 2018. Accessed on 05.05.2018).

Evaluation

1. Emphasis will be on student's ability to apply concepts generatively rather than to test memory and to encourage intersectional thinking. Therefore all the readings may be treated as applying to all units in terms of concepts and techniques therein.

Practicals (14 hours)

1. Students may submit for evaluation either one full-length academic essay or produce a portfolio that re-writes or re-scripts or reviews texts they select (with the assistance of the teacher) from contemporary Indian media such that units 2 3 and 4 each are represented in the portfolio. Alternatively students may choose to focus on any one of units 2/3/4 should they have special aptitude for or interest in any area.

2. The objective of the course is to enable the student to intervene as an informed gender-ethical respondent to media narratives so any mode of media that permits this analysis such as blog-posts television programming new media including social media documentary and other short films news coverage may also be admitted such that they are equivalent in total effort to a full-length academic essay.
3. Students may also be encouraged to create samplers and portfolios of contemporary coverage thematically.
4. Students are to be encouraged to find and bring supplementary texts to classroom discussion for all units.

Teaching Plan
PaperS11: Applied Gender Studies: Media Literacies

Week 1 -- Unit 1: Gender/s: concepts and frameworks

Topics: Femininities/Masculinities Cis/Trans bodies Heterosexuality/ Homosexuality/ Heteronormativity/ Heteropatriarchy Sexism/Privilege/Biology/Reproduction

Texts:

Kandasamy Meena. ‘Screwtiny’ ‘Pride goes before a full-length mirror’ ‘Joiussance’ and ‘Backstreet Girls’.

Dasgupta R.K and Gokulsing K. M. Introduction: Perceptions of Masculinity and Challenges to the Indian Male.

Revathi A. *A Life in Trans Activism*. Pp. 158—168.

Nadimpally S. and V. Marwah. ‘Shake Her She is Like the Tree That Grows Money!’

Rege Sharmila ‘Dalit Women Talk Differently: A Critique of 'Difference' and Towards a Dalit Feminist Standpoint Position’.(Practicals as applicable to unit)

Week 2 -- Unit 1 (contd.)
Week 3 -- Unit 1 (contd.)
Week 4 -- Unit 1 (contd.)
Week 5 -- Unit 2: Analysing gender in advertising

Topics: The use of gendered stereotypes and privilege in advertising hegemonic and normative ideas of gender and sexuality in selling and buying products consumption of goods bodies commodification and objectification the reach and memorability of advertising matrimonial and personal ads and reinforcement of caste/class/gender binaries.

Readings

Chaudhuri Maitrayee. ‘Gender and Advertisements: The Rhetoric of Globalisation’.

Jha Sonora and Mara Adelman. 'Looking for love in all the white places: a study of skin colour preferences on Indian matrimonial and mate-seeking websites.'

(Practicals as applicable to unit)

Week 6 -- Unit 2 (contd.)

Week 7 -- Unit 2 (contd.)

Week 8 -- Unit 3: Analysing representations of gender in reporting and journalism

Topics: Vocabulary of news media coverage in relation to gender representation of masculine/feminine/non-dimorphic bodies Re-narrativizing this vocabulary productively difference in coverage of stories of obviously 'gendered' subjects such as rape heroism war domestic violence sexual harassment and supposedly 'neutral' subjects like labour rights or work and wages or health or politics advocacy networks for various minority subjects persistence of sexism in new media

Readings

*Khabar Lahariya*FAQ (http://khabarlahariya.org/faqs/) and 'Open letter to our Male

Colleagues of the Media World from Khabar Lahariya Editors'.

Dixit Neha and Sen Orijit. 'The Girl Not from Madras.' and 'It is Hard to be a Journalist in India. Is it Harder if you're a Woman?'

For visually challenged students replace second reading with 'Sarpanch Woodcutter

Handpump Mechanic: Dalit Women in UP tell Women@Work Stories'.

(Practicals as applicable to unit)

Week 9 -- Unit 3 (contd.)

Week 10 -- Unit 3 (contd.)

Week 11 -- Unit 4: Gender as represented in film (fiction and nonfiction/documentary)

Topics:

Narrative time available to male/female/trans subjects use of normative heterosexuality and gender privilege in plots casting narrative development and marketing of films the Bechdel test: the importance of clearing it and the implications for mainstream narrativization consistently failing the test documentary films for presentation of alternative narratives.

Readings

View and discuss *any one* of the feature films: *Dangal* or *Chak De* or *Pink.*

For visually challenged students --

Phadke Shilpa Sameera Khan and Shilpa Ranade. Why Loiter? Women and Risk on Mumbai Streets. Pp. 65—106.

View and discuss the documentary films *Unlimited Girls* and *Newborns*.

For visually challenged students:
Agnihotri Anita. ‘The Peacock.’ *Seventeen*. New Delhi: Zubaan 2011. 69-79 and Paromita Vohra's ‘Interview with Veena Mazumdar part 1’ and ‘Interview with Veena Mazumdar part 2’. *Unlimited Girls* footage. Point of View.
Siddiqui Gohar. ‘Behind her Laughter is Fear: Domestic violence and transnational feminism’.
Week 12 -- Unit 4 (contd.)
Week 13 -- Unit 4 (contd.)
Weeks 14 -- Unit 4 (contd.)

For entire course: Practical work done by students is to be shared in class to enable dissemination of knowledge produced.

Facilitating the Achievement of Course Learning Outcomes
PaperS11: Applied Gender Studies: Media Literacies

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Understanding concepts of skill to be taught	Interactive discussions with students to guide them towards skill based learning	Reading theoretical material together in small groups working in peer groups to discuss material
2.	Application of skill	Practical application of skill performed under supervision of teacher	Producing assignments preparing project folders
3.	Demonstrating conceptual understanding and practical application of skill in tests and examinations	Discussing exam questions and answering techniques	Class tests

Keywords

Femininities
Masculinities

Heteronormativity
Heteropatriarchy
Social Reproduction
Intersections
Resistance

Course Committee

Dr Aneeta Rajendran Gargi College (Coordinator)
Ms A. Jeyakirthana J. Gargi College
Rina Ramdev, Sri Venkateswara College
Vinita Chandra, Ramjas College

B. A./B. COM. PROGRAMME

CORE ENGLISH LANGUAGE

General Course Statement

1 The course will retain streaming The structure of three graded levels of English language learning is required in a diverse central university like Delhi University to address the differential learning levels of students and achieve the desired competence

2 The existing English A B and C will be renamed as English Language through Literature English Fluency and English Proficiency respectively This will remove any discriminatory attributes in the existing nomenclature and refocus the pedagogic exercise on the respective objectives of the three streams in an academically thorough and non-hierarchical way

3 The existing criteria for streaming was discussed thoroughly in the context of the almost complete collapse of English B and English C classes across colleges This structural collapse has led to severely compromised language acquisition opportunities for BA/BCom students At present 98% of BA/BCom programme applicants are from boards where English is offered as a subject in class XII Currently in Delhi University a student with minimum pass marks in English in Class XII will do the same English course as a student scoring above 90% Such guaranteed variance in competences and standards in the classroom is a huge pedagogic challenge that stalls the aim of achieving any tangible proficiency in the language over two semesters

In order to address this reality which was further aggravated by the reduction in the language teaching span in CBCS to two semesters the committee concluded that it is imperative to have additional streaming criteria NOT eligibilityor admissioncriteria to benefit the students in the classroom and in their careers A hugely participative student feedback survey was conducted online Thousands of BA/BCom Delhi University students responded to the detailed questionnaire and helped us to our conclusions

Based on these findings and the consensus in our meetings the BA/BCom Programme Cluster Subcommittee proposes the following:

As 98% of the BA/BCom Programme students have done English in class 12 streaming will be now based on their Class XII marks in English There will be three streams:

1. 80% and above: **ENGLISH LANGUAGE THROUGH LITERATURE**
2. 60% and above up to 80%: **ENGLISH FLUENCY**
3. Less than 60%: **ENGLISH PROFICIENCY**

- We have retained the present Delhi University Rule of streaming students who have done English up to Class X and Class VIII to ENGLISH FLUENCY and ENGLISH PROFICIENCY respectively to take care of the 2% who may not have done English up to Class XII
- We have provided a 10% relaxation in Class XII English marks while streaming for students who have studied English Elective in class XII

This proposal is the most academically sound non-hierarchical and inclusive one we could arrive at that successfully addresses the pedagogical and learning imperatives in English language teaching

The revised syllabus proposed here is in sync with the CBCS outline. Additionally this syllabus works out the specifics of language learning required to enable the students of Delhi University in the process of language acquisition and proficiency, as it integrates critical thinking, reading, writing, and speaking capabilities, without compartmentalising any one or two as the expected focus or outcome of language study. For this purpose, a compiled list of suggested readings collated by the Department of English Delhi University can be finalised .

The detailed syllabus with suggested readings teaching plansa testing/evaluation pattern and learning outcomes for two semesters under CBCS is as follows:

ENGLISH LANGUAGE THROUGH LITERATURE I & II
ENGLISH FLUENCY I & II
ENGLISH PROFICIENCY I& II

A -- ENGLISH LANGUAGE THROUGH LITERATURE

Course Objectives

This course aims to

- develop in students the ability and confidence to process understand and examine different kinds of texts verbal and written that they encounter in everyday life
- enable students to identify and understand social contexts and ethical frameworks in the texts they encounter
- encourage suitable research; to recognize sources; to distinguish fact from opinion/editorialization; produce objective versus subjective pieces
- teach skilled comprehension; listening/reading; skimming; summarising; précis writing; paraphrasing; note making
- identify key topics/arguments/ideas
- accomplish writing goals: creating an essay; writing a thesis statement; producing topic sentences;developing organised paragraphs; evolving the skill of producing suitable transitions between paragraphs
- enable students to write in expository argumentative and descriptive modes

- help students identify and use the characteristic features of various writing forms: letters programmes reports/press-releases; newspaper hard news; feature articles; fiction and nonfiction
- enable students to choose between expository argumentative descriptive and narrative writing styles to assemble their own writing
- inculcate confident expression: to enable students to articulate their own views confidently because their language skills sufficiently empower them to converse research and collate information from various textual sources be these verbal or written

COURSE CONTENT FOR SEMESTERS I / II

Unit 1
Understanding Everyday Texts

This unit aims to help students understand that we are surrounded by texts So thinking about texts reading writing and comprehension are necessary life skills not merely language skills

Reading: Texts may include reportage open letters campaigns social reports etc Students will practis skimming scanning analysing interpreting
Writing: Descriptive passage making notes drafting points creating a program sheet paragraphs outlines drafts etc
Speaking: Make short presentations 2-3 minutes long showcasing their understanding of any topical issues
Listening and responding to short presentations
Grammar/Vocabulary: Tenses -- verb tenses and the ability to use them in a variety of contexts

Suggested Readings:

Edwards Adrian 'Forced displacement worldwide at its highest in decades' *UNHCRorg*
UNHCR http://wwwunhcrorg/afr/news/stories/2017/6/5941561f4/forced-displacement-worldwide-its-highest-decadeshtml# Accessed 1 June 2018
Jadhav Radheshyam 'Groom wanted: Trader peon…anyone but a farmer' *Times News Network* 1 Jan 2018 https://timesofindiaindiatimescom/city/chandigarh/groom-wanted-trader-peonanyone-but-a-farmer/articleshow/62321832cms Accessed 1 June 2018
Knapton Sarah 'Selfitis' -- the obsessive need to post selfies -- is a genuine mental disorder
say psychologists' *The Telegraph*15 December 2017 https://wwwtelegraphcouk/science/2017/12/15/selfitis-obsessive-need-post-selfies-genuine-mental-disorder/ Accessed 1 June 2018
'13 letters every parent every child should read on Children's Day' *The Indian Express* 10
November 2014
http://indianexpresscom/article/lifestyle/feelings/12-letters-every-parent-every-child-should-read-on-childrens-day/ Accessed 1 June 2018

Unit 2
Understanding Drama
This unit focuses on dramatic texts centre human communication; the focus will be to see how speech is connected to character and situation

Reading one-act/short plays to identify different elements of drama characterization/ conflict/ plot etc
Writing: Rewriting dialogue for a character; writing an alternative playscript for a scene with stage directions; practicing expository writing; writing analytical pieces about the plays
Speaking: Learning to use one's voice and body to perform/enact a character
Listening: Watching plays live or recorded; studying why actors perform the way they do
Grammar/Vocabulary: Observing and learning the us of the first person/second person/third person address

Suggested Readings:

Lakshmi CS 'Ambai' 'Crossing the River' *Staging Resistance: Plays by Women in Translation* edited by Tutun Mukherjee Oxford: Oxford University Press 2005

Unit 3
Understanding Poetry

Poetic texts centre the use of language in clear and striking ways: students will learn how poetic language can help them attain brevity clarity depth and complexity in verbal and written expression

Reading poetry to identify tone imagery rhythm rhyme and use of tropes
Writing and reviewing poems with particular emphasis on formal elements; paraphrase and analysing poems to produce argumentative interpretations of poems
Speaking:reading poetry out loud as in poetry slam in order to listen to tone emphasis etc
Listening to others' poetry and preparing responses

Grammar/Vocabulary: Modifiers Synonyms Antonyms Homophones Simile Metaphor

Suggested Readings:

Angelou Maya 'Caged Bird' *The Complete Collected Poems of Maya Angelou* New York: Random House Inc 1994
Ezekiel Nissim 'Goodbye Party For Miss Pushpa TS' *Collected Poems* New Delhi: Oxford University Press 2005
Okara Gabriel 'Once Upon a Time' *Gabriel Okara: Collected Poems* Nebraska: University of Nebraska 2016
Lawrence DH 'Last Lesson of the Afternoon' *The Complete Poems of DH Lawrence* Hertfordshire: Wordsworth Editions 1994

Unit 4
Understanding Fiction

Narrative texts use language to recreate experience: students will learn how to order their experiences into meaningful narratives

Reading a short story to identify themes plot structure characterisation and narrative voice
Rewritingthe story from another perspective to redevelop plot and characters
Speaking: discussingthe formal elements of a piece of fiction of their choice
Listening to audio clips of writers reading their work/work read aloud to study how fiction uses literary devices and also rhythm pauses punctuation etc

Grammar/Vocabulary: Imperatives Conditional Clauses Transitions

Suggested Readings:

Kumar E Santhosh 'Three Blind Men describe an Elephant' *Indian Review* http://indianreviewin/fiction/malayalam-short-stories-three-blind-men-describe-an-elephant-by-e-santhosh-kumar/ Accessed 1 June 2018

Mistry Rohinton 'The Ghost of FirozshaBaag' *Tales from Firozsha Bagh* McClelland & Stewart 1992

Joshi Umashankar 'The Last Dung Cake' *The Quilt from the Flea-market and Other Stories* Delhi: National Book Trust 2017

Unit 5
Creating Your Own Voice

This unit helps students understand that the creation of a unique personal voice is possible through an understanding of the mechanics of language This section will study how different audiences lead us to modify what we wish to say so that our thoughts become accessible and communication is successful

Reading: Texts may include columns opinion and editorial pieces from newspapers magazines social media online news and e-zines
Writing: Examine the process of writing: drafting editing and revising; respond to what you are reading in the form of a personal essay preliminary forms can include social posts or blogs structured as brief personal essays
Speaking about thematically similar content to different audiences to help students understand how the listener affects form and content
Listening: Students' presentations can supply the core listening task; listen to texts on similar themes addressed to different audiences film clips from feature and documentary films; songs on the same theme

Grammar/Vocabulary: Register tone word choice

Suggested Readings:

Dixit Neha 'Justice Denied: A Road Accident That Wasn't a Lynching That Was' *The Wire* 12 April 2018 https://thewirein/rights/justice-denied-a-road-accident-that-wasnt-a-lynching-that-was Accessed 4 June 2018

Khanna Twinkle 'This Diwali let outdated traditions go up in smoke' in 'Mrs Funnybones' *The Times of India* 15 October 2017 https://blogstimesofindiaindiatimescom/mrsfunnybones/this-diwali-let-outdated-traditions-go-up-in-smoke/ Accessed 13 June 2018

TESTING AND EVALUATION

Internal Assessment: Of 20 marks 10 marks willbe allocated for assessment of reading and writing assignmentsand 10 marks for assessment of speaking and listening test

Semester I/II Final Examination 75 marks

Reading and Writing skills:

- Unseen comprehension passage 650 words to test reading comprehension critical thinking and vocabulary skills 15 marks
- Questions based on literary texts: to test awareness of literary form and context through comprehension testing 2 x 15 = 30 marks
- Questions testing composition skills: descriptive passage; personal essay; paraphrasing poem; re-writing story-ending etc 2 x 10 = 20 marks

Grammar: Different grammar topics to be tested via exercises of editing/rewriting a given passage10 marks

Teaching Plan

Week 1 – Introduction; Unit 1 --Understanding Everyday Texts
Week 2 – Unit 1 contd
Week 3 – Unit 1 contd
Week 4 – Unit 2 -- Understanding Drama
Week 5 – Unit 2 contd
Week 6 – Unit 2 contd
Week 7 – Unit 3 -- Understanding Poetry
Week 8 – Unit 3 contd
Week 9 – Unit 4 -- Understanding Fiction
Week 10 – Unit 4 contd
Week 11 – Unit 4 contd
Week 12 – Unit 5 -- Creating Your Own Voice
Week 13 – Unit 5 contd
Week 14 – Unit 5 contd and summing up

General Template for Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Language through literature
Verbal and written texts
Social and ethical frameworks
Listening and reading comprehension
Argumentative descriptive and narrative writing styles
Confident self-expression

COURSE CONTENT FOR SEMESTERS III / IV

Unit 1
Understanding Life Narratives

Giving students the skills to document their own lives meaningfully; journals, memoirs, and autobiographical writings can be excellent tools for personal reflection and growth, therapeutic as well as a method for organising one's own thoughts in a fashion that helps one live meaningfully

Readingsections from life narratives biographies autobiographies diary entries
Writing a statement of purpose for university applications; CV/resume; daily/weekly journal
Speaking to your class to persuade them to do something public speech
Listening to public speeches like convocation addresses, political speeches, TED Talks to trace structure of argument and worldview; to observe the use of description, persuasion, and argument

Grammar/Vocabulary: Action Verbs; Active and Passive voice

Suggested Readings:

Das Kamala ‘The Park Street Home’ *My Story* Kottayam: DC Books 2009
Singh Mayank Mayank Austen Soofi Selected extracts from ‘I Had Come Too Far’ *Nobody Can Love You More* Delhi: Penguin Books 2014
Bhattacharjee Kishalay ‘Back To Where I Never Belonged’ *First Proof: The Penguin Book of New Writing From India* Delhi: Penguin Books India 2005
Issacson Walter Selected extracts from *Steve Jobs* New York: Simon and Schuster 2011

Unit 2
Exploring Poetry

Here, students are trained to use the techniques of poetry to write in poetic form; they understand how the concept of beauty works through access to aesthetic forms; they learn how to express the same thought in different ways and observe how form impacts meaning; these skills can become tools for personal confidence in linguistic use

Reading: Using context to read effectively; identifying elements of poetics in different forms of poetry prose poems / slam poetry
Writing slam poetry; writing a critical response to a poem
Listening: Reciting/performing poetry; listening to audio/video clips of poets reading their poetry to appreciate the significance of pauses, rhythm etc

Grammar/Vocabulary: Denotation/Connotation

Suggested Readings:

Nair, Rukmini Bhaya ‘Gargi’s Silence’ *Yellow Hibiscus: New and Selected Poems* Delhi: Penguin 2004
Nongkynrih Kynpham Sing ‘Light-In-The-Night For Amanda’
Seth, Vikram ‘Part One’ *The Golden Gate* Faber and Faber 1999
Charara Hayan ‘Usage’ *Something Sinister* Carnegie Mellon University Press 2016

Unit 3
Exploring Drama

Such explorations highlight the rhetorical possibilities of drama through an understanding of its form and mechanics; students learn how to handle conflict, how to have meaningful conversations, and, above all,learn how one’s words and gestures impact others

Reading a one-act/ longer play to understand the interaction of dramatic forms/elements and social context
Writing a critical response to the dramatic text; writing the script for a skit/short play, keeping in mind formal features like characterisation, plot development, stage directions etc

Speaking: Students learn to use their voices and bodies to perform/enact skits in groups
Listening to a radio play to appreciate the aural elements of drama

Grammar/Vocabulary: Direct/ Indirect Speech; Phrases and Idioms; Tone and register

Suggested Readings:

Sarkar, Badal 'Beyond the Land of Hattamala' *Beyond the Land of Hattamala and Scandal in Fairyland* Calcutta: Seagull Books 1992

Unit 4
Exploring Fiction the novella

Narrative texts can be seen as a tool for exploring reality including contests of what should be accepted as real Students will learn how to write narrative and through narrative to examine their own responses to issues confronting them

Read a longer piece of fiction to discern narrative voice, narrative structure, character development, while locating the text in its socio-historical context
Write your own short story/novella; speculative fiction can be particularly useful as young people are often in positions of contest with the social reality afforded to them; read and review short stories/novellas/novels
Speak: Initiate discussion about a novella, drawing upon the critical reading skills developed by students in the previous semester; focus will be on broadening their repertoire of reading: texts chosen and responded to for personal pleasure
Listen to audio clips/ videos of writers talking about what writing means to them; audio clips of books being read aloud to enable discussion of reading styles pauses punctuation etc

Grammar/Vocabulary: Punctuation pauses manner of reading/speaking/crafting complex sentences

Suggested Reading:

Cisneros, Sandra *The House on Mango Street* Knopf Doubleday Publishing Group, 2013

Unit 5
Writing your own academic essay / paper for the classroom

Using language skills learned over the course, students are to create academic documents such as term papers, reports and assignments They should examine and revisit earlier such submissions to learn how to improve and edit these better; to learn to identify consult and cite the right sources to avoid plagiarism; to recognise and rectify bias in their own writing: biases such as those of class/caste/race/gender/sexuality/religion can be discussed in class
Writing, revising and formatting drafts of essays analysing the coherence of arguments; perspectives on a topic; balance of presentation; students can testtheir

ability to choose between various forms of information/fact/opinion; they can createquestionnaires, conducting surveys; edit and and create bibliographies and checklists
Speaking: Students should beable to tell the class what their core idea is in the essay / paper, and why they have chosen a particular topice or idea; they should be able to debate various points of view on the same topic
Listening to others views and being able to figure out which arguments are key and why; examining ideology and location of speakers

Grammar/Vocabulary: Paragraphs topic sentences and transitions

Suggested Readings:

Patel Raj and Moore Jason 'How the chicken nugget became the true symbol of our era' *The*
Guardian, 8 May 2018
https://wwwtheguardiancom/news/2018/may/08/how-the-chicken-nugget-became-the-true-symbol-of-our-eraAccessed 4 June 2018
Latest editions of the MLA and APA style sheets

TESTING AND EVALUATION

Internal Assessment: Of 20 marks, 10 marks are to be allocated for assessment of reading and writing assignmentsand 10 marks for assessment of speaking and listening test

Semester III/ IVFinal Examination 75 marks

Reading and Writing skills:

- Unseen comprehension passage 750 words to test reading comprehension critical thinking and vocabulary skills 15 marks
- Questions based on literary texts: to test awareness of literary form and context through comprehension testing 2 x 15 = 30 marks
- Questions testing composition skills: essay statement-of-purpose essay / argumentative / personal / descriptive ; diary/journal; questionnaire; dramatise story/write short scene etc 2 x 10 = 20 marks
- Question testing academic writing formats via exercise of correcting citation or bibliographical entry 5 marks

Grammar: Different grammar topics to be tested via exercise of editing/rewriting a given passage 5 marks

Teaching Plan

Week 1 – Introduction& Unit 1 -- Understanding Life Narratives
Week 2 – Unit 1 contd
Week 3 – Unit 1 contd
Week 4 – Unit 2 -- Exploring Poetry

Week 5 – Unit 2 contd
Week 6 – Unit 3 -- Exploring Drama
Week 7 – Unit 3 contd
Week 8 – Unit 3 contd
Week 9 – Unit 4 -- Exploring Fiction Novella
Week 10 – Unit 4 contd
Week 11 – Unit 4 contd
Week 12 – Unit 5 --Writing your own academic essay / paper for the classroom
Week 13 – Unit 5 contd
Week 14 – Unit 5 contd & Summing Up

General Template for Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Keywords

Language through literature
Verbal and written texts
Social and ethical frameworks
Listening
Reading
Comprehension
Argumentation
Descriptive writing
Narrative writing

Committee Members

Nidhi Bhandari, Kamla Nehru College -- CoordinatorEnglish Language through Literature I & II
Aneeta Rajendran, Gargi College
Indira Prasad, Miranda House
Nupur Mittal, SPM College
Neenu Kumar, Aditi Mahavidyalaya
Sachin N, Dyal Singh College

BA/ B COM PROGRAMME CORE ENGLISH LANGUAGE:

B -- ENGLISH FLUENCY

Course Objectives

This course is intended for students who possess basic grammatical and vocabulary skills in English but may not be able to effectively communicate in their everyday contexts The course aims to equip them with skills that will help them interact with people around their personal institutional and social spaces The course will help students to

- describe or express their opinions on topics of personal interest such as their experiences of events, their hopes and ambitions
- read and understand information on topical matters and explain the advantages and disadvantages of a situation
- write formal letters, personal notes, blogs, reports, and texts on familiar matters
- comprehend and analyse texts in English
- organise and write paragraphs and a short essaysin a variety of rhetorical styles

COURSE CONTENTS FORSEMESTERS I / II

Unit 1
In the University

Introducing oneself -- Note-making
Pronunciation Intonation – Nouns, Verbs, Articles

- Introduce yourselves as individuals and as groups -- group discussion exercise Take notes on your fellow students' introductions
- Introduce characters from the text you are reading via posters

Tales of Historic Delhi by Premola Ghose

Unit 2
In the domestic sphere

Diary/ Blog writing
Modifiers, Prepositions, Conjunctions

- Write a diary entry and convert it into a blog post
- Convert a transcript/ script/ piece of dialogue into a diary entry/ blog post

'The Lost Word' by Esther Morgan
Squiggle books by Natasha Sharma

Unit 3
In public places

CV Job applications
Tenses and concord

- Write the CV of a fictional character
- Write the perfect job application for your dream job

'Amalkanti' by Nirendranath Chakrabarti
Extract from *Bhimayana*

Unit 4
In the State

Research -- Filing an FIR, making an RTI request, submitting a consumer complaint
Active & Passive voice; idioms

- Find out what the procedure is for making a complaint about trees being cut in your neighbourhood
- Draft a formal letter requesting information about the disbursal of funds collected by a residents' welfare association

Where the Wild Things Are by Maurice Sendak
rtionlinegovin/indexphp
consumerhelplinegovin/consumer-rightsphp
wwwjaagorecom/know-your-police/procedure-of-filing-fir
wwwconsumercomplaintsin/municipal-corporation-of-delhi-b100274

Unit 5
Interface with Technology

Book/film reviews
Punctuation

- Write a review of a text you have read in class
- Record a collaborative spoken-word review of the latest film your group have all seen

Priya's Shakti by Ram Devineni, Lina Srivastava and Dan Goldman
wwwpriyashakticom/priyas_shakti/
theladiesfingercom/yep-headlines-reporting-domestic-violence-are-crap/

Teaching Plan

Week 1 – Introduction& Unit 1 -- In the University
Week 2 – Unit 1 contd
Week 3 – Unit 2 --In the domestic sphere
Week 4 – Unit 2contd
Week 5 – Unit 2contd
Week 6 – Unit 3 --In public places
Week 7 – Unit 3 contd
Week 8 – Unit 3 contd
Week 9 – Unit 4 --In the State
Week 10 – Unit 4 contd
Week 11 – Unit 4 contd
Week 12 – Unit 5 --Interface with Technology
Week 13 – Unit 5 contd
Week 14 – Unit 5 contd & Summing Up

General Template for Facilitating the Achievement of Course Learning Outcomes

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Keywords

Effective communication
Listening
Speaking
Reading and writing
Communicative tasks and activities
Familiar contexts
Professional contexts
Social contexts

COURSE CONTENTS FOR SEMESTER III / IV

Unit 6
In the University

Elements of debate/ Academic writing
Argument and Textual evidence

- Prepare a presentation on a topic you have seen debated on television; delineate the arguments and textual evidence used by both sides
- Write a paragraph on any topic you are studying in any of your courses at present; cite all sources of information you use

'Sisters' by Saleem Peeradina
kafilaonline/2016/09/20/the-radical-significance-of-the-du-photocopy-case-for-global-copyright/

Unit 7
In the domestic sphere

Informal/ Epistolary writing
Descriptive & Expository writing

- Write a letter to your daughter -- in your own mother's voice; use a text you have read in class as a sample
- Prepare a presentation on a fictional place as though you have visited it

scrollin/article/801848/to-jyotiba-from-savitribai-phule-these-arent-love-letters-but-tell-you-what-love-is-all-about
Extract from *Between Ourselves: Letters between Mothers and Daughters* Virago

Unit 8
In public places

Dialogue: Conversation/ Interview between fictional characters
Narrative logic; connectives & transitions

- Group exercise: Prepare an interview between a refugee and her prospective landlord
- Write a conversation you have overheard in a public place recently

wwwaljazeeracom/indepth/features/2016/10/dear-donald-trump-letter-syrian-refugee-161013173005294html
'We Sinful Women' by KishwarNaheed

Unit 9
In the State

Paragraph writing
Brainstorming planning/outline rough drafts editing

- Work in groups to brainstorm ideas for a paragraph on any social topic
- Prepare individual outlines and rough drafts
- Peer review and edit each others' writing

Squiggle books by Natasha Sharma
Extract from 'The Transformation of Silence into Language and Action' by Audre Lorde

Unit 10
Interface with technology

Creative writing/ Social media presencep
Affective & Poetic expression; rhetoric

- Write a Facebook post announcing a cultural event
- Write a poem of 140 characters to post on twitter
- Evaluate your favourite WhatsApp group's last 10 posts

Extracts from *Haroun and the Sea of Stories* by Salman Rushdie

Evaluation:

Internal assessment (25 marks)
Reading & Writing assignment(10 marks)
Oral listening & speaking test(10 marks)
Attendance: 5 marks

FINAL EXAM 75 marks

Semester I/II

Book or film review(15 marks)
Comprehension passage(15 marks)
RTI request or FIR(10 marks)
Dialogue or Interview(10 marks)
Diary or blog post(10 marks)
Proofreading/Punctuation passage(5 marks)
Note-making(5 marks)
Facebook or Twitter post(5 marks)

Semester III/IV

Literature review(15 marks)
Comprehension passage(15 marks)
Debate(15 marks)
Job application(10 marks)
Informal letter(10 marks)
Proofreading/Punctuation passage(5 marks)
Paragraph writing(5 marks)

Teaching Plan

Week 1 – Introduction& Unit 1 - In the University
Week 2 – Unit 1 contd
Week 3 – Unit 2 - In the domestic sphere
Week 4 – Unit 2contd
Week 5 – Unit 2contd
Week 6 – Unit 3: In public places
Week 7 – Unit 3 contd
Week 8 – Unit 3 contd
Week 9 – Unit 4: In the State
Week 10 – Unit 4 contd
Week 11 – Unit 4 contd
Week 12 – Unit 5: Interface with Technology
Week 13 – Unit 5 contd
Week 14 – Unit 5 contd & Summing Up

General Template for Facilitating the Achievement of Course Learning Outcomes

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Keywords

Effective communication
Listening
Speaking
Reading
Writing
Communicative tasks and activities
Familiar context
Personal communication
Professional communication
Social communication

Committee Members

Kuntal Tamang, Motilal Nehru College – Coordinator (English Fluency I & II)
Shivranjani Singh, Dyal Singh College
Hari Prasad, Zakir Husain Delhi College
Rohith P, DDU College
Nisha Singh, Bharati College
Sachin N, Dyal Singh College

BA/ B COM PROGRAMME CORE ENGLISH LANGUAGE:

C ENGLISH PROFICIENCY

Course Objectives

The English Proficiency course is intended for students who have had inadequate exposure to English and hence exhibit a very low level of proficiency in the language – difficulty in comprehending simple texts, limited vocabulary, a poor grasp of basic syntactical structures, and an inability to speak or write the language with confidence. The course that is spread over two semesters aims to redress these issues and aims to

- enhance comprehension skills and enrich vocabulary through the reading of short and simple passages with suitable tasks built around these
- introduce simple syntactical structures and basic grammar to students through contextualized settings and ample practice exercises so that they can engage in short independent compositions
- introduce the sounds of the language and the essentials of English pronunciation to students in order to remove the inhibitions experienced by them while speaking English
- acquaint students with social formulae used to perform various everyday functions so that they can converse in English in simple situations

COURSE CONTENTS FOR SEMESTER I / II

Unit 1
Reading and Comprehension - I

Note: The unit names are indicative only and identify core language areas that are targeted through the course. The learning of various language skills needs to happen in an integrated fashion. It is therefore imperative that for every unit learners should work through the whole range of tasks in the prescribed readings irrespective of the title of the unit.

- Short and simple passages from the prescribed books
- These texts are to be used to enhance reading and comprehension skills of learners through various textual tasks such as reading aloud, sentence completion, true / false activities, re-ordering jumbled sentences, identifying central ideas, supplying alternative titles, attempting short comprehension questions, etc.
- Learners are encouraged to exploit the recommended books beyond the prescribed sections
- The end-semester examination will include the testing of the comprehension of an unseen passage of an equivalent level

Prescribed readings:

A Foundation English Course for Undergraduates: Reader I, Delhi: Oxford University Press, 1991, pp. 1 - 36 Units 1 - 6
Everyday English Delhi: Pearson, 2005, pp. 1 - 15 Units 1 - 3 & 21 - 31 Units 5 - 6

Unit 2
Learning about words

Students cultivate the habit of using a dictionary to learn about words - their spelling, pronunciation, meaning, grammatical forms, usage, etc. Students are introduced to word associations, the relationships between words – synonyms, antonyms, homonyms, homophones. They learn the use of prefixes and suffixes; commonly confused words; phrasal verbs and idioms

The specific reading prescribed for this unit is to be used in conjunction with the vocabulary sections in the other recommended course texts, where activities like matching, sorting, and fill-in-the-blanks are used to engage the learners with words.

As a semester-long project the learners could be required to prepare 'mini-dictionaries' of their own, consisting of unfamiliar words they come across on a daily basis

Prescribed reading:

Everyday English Delhi: Pearson, 2005, pp. 36 - 43 Unit 8

Unit 3
Basic Grammar Rules - I

Subject-verb agreement; tenses; modals; articles; prepositions; conjunctions

The prescribed reading for this unit is to be supplemented by the grammar tasks contained in the other recommended course books to provide intensive practice to learners

Prescribed reading:

Developing Language Skills I, Delhi: Manohar, 1997, pp. 186 - 195 & 206 - 209 Units 2 3 & 5 of the 'Grammar' section

Unit 4
Writing Skills - I

This section will introduce students to the structure of a paragraph; they will write a short guided composition of up to 100 words. These skill is to be practised through activities such as supplying topic sentences to given paragraphs, completing given paragraphs, expressing given facts or information from tables and expressing it in paragraphs, re-ordering jumbled sentences, and then re-writing them as connected paragraphs, using suitable linking devices etc

Relevant sections from the other recommended course books are to be used for this purpose in addition to the prescribed reading for this section

Prescribed readings:

Everyday English, Delhi: Pearson, 2005, pp. 21 - 31 Units 5 - 6
A Foundation English Course for Undergraduates: Workbook I, Delhi: Oxford University Press, 1919, pp. 1 - 31 Units I - V

Unit 5
Conversing - I

Students will learn to listen to he sounds of English; the essentials of English pronunciation; conversational formulae used for greetings. After introducing themselves and others, students will learn correct modes of thanking, wishing well, apologizing,excusing oneself, asking for and giving information, making offers and requests, and giving orders.

In addition to the prescribed reading for this unit, the 'Speaking' sections at the end of the first five units of the *Everyday English* text should be used

Prescribed reading:

Developing Language Skills I, Delhi: Manohar, 1997, pp. 8 - 26 Units 1 - 5 of 'Oral Communication: Speech Patterns'

Teaching Plan
Teaching Learning Process

Since language skills can only be learnt and mastered through the teaching-learning process, instruction needs to be learner-centric The class time is to be taken up with hands-on activities by learners, involving reading aloud / silently, speaking, listening, and writing. Peer and group work should be used extensively The teacher is to act as a facilitator, setting up and overseeing learner tasks and providing stimulus encouragement and corrective inputs as and when necessary. The teacher is also expected to source additional related material and activities pitched at an appropriate level of difficulty, to plug in gaps in the prescribed readings as well as to extend the knowledge of the learners and to hone their skills

Teaching Plan for Semester I / II

Week 1 – Introduction; *A Foundation English Course for Undergraduates: Reader I*, pp. 1 – 15 Units 1 - 3
Week 2 – *A Foundation English Course for Undergraduates: Workbook I*, pp. 1 – 14 Unit I
Week 3 – *A Foundation English Course for Undergraduates: Reader I*. pp. 17 – 33 Units 4 –6
Week 4 – *Developing Language Skills I*, pp. 186 – 189 Unit 2 of 'Grammar'; *Everyday English*, pp. 1- 9 Units 1 – 2
Week 5 – *Everyday English*, pp. 10 - 15 36 - 43 Units 3 & 8
Week 6 – *English at the Workplace II*,pp. 10 - 13 Unit 3; *Developing Language Skills I*, pp.1 – 13 Units 1 & 2 of 'Oral Communication: Speech Patterns'
Week 7 – *A Foundation English Course for Undergraduates: Workbook I*,pp. 15 – 20 Unit II; *Everyday English*, pp. 21 - 27 Unit 5
Week 8 – *Everyday English*, pp. 28 - 31 Unit 6; *Developing Language Skills I*, pp,18 – 21 Unit 4 of 'Oral Communication: Speech Patterns'
Week 9 – *Developing Language Skills I*, pp. 189 – 195 Unit 3 of 'Grammar'
Week 10 – *A Foundation English Course for Undergraduates: Workbook I*, pp. 21 – 22 Unit III; *Developing Language Skills I*, pp. 14 – 18 Unit 3 of 'Oral Communication: Speech Patterns'
Week 11 – *Developing Language Skills I*, pp. 21 - 26 Unit 5 of 'Oral Communication: Speech Patterns'
Week 12 – *Developing Language Skills I*,pp. 206 – 208 Unit 5 of 'Grammar'
Week 13 – *A Foundation English Course for Undergraduates: Workbook I,* pp. 23 – 27 Unit IV
Week 14 - *A Foundation English Course for Undergraduates: Workbook I,*pp. 28 – 31 Unit V

General Template for Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
Understanding concepts	Interactive discussions in small groups in Tutorial classes	Reading material together in small groups initiating discussion topics participation in discussions
Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Note: The entire course is practical in nature The prescribed readings are rich in tasks and activities that aim at developing essential language skills. Working their way through these tasks will give the learners hands-on practice in the use of these skills.

References

A Foundation English Course for Undergraduates: Reader I, Delhi: Oxford University Press,1991
A Foundation English Course for Undergraduates: Workbook I, Delhi: Oxford University Press, 1991
Everyday English, Delhi: Pearson, 2005
Developing Language Skills I, Delhi: Manohar, 1997

Additional Resources:
English at the Workplace, Delhi: Macmillan, 2006

Assessment Methods

Since the class is conceived as learner-centric and built around tasks that require learners to actively use various language skills, formative assessment can and should be used extensively. The focus here could be on skills and activities that are harder to test in a written evaluation, such as speaking and listening skills, dictionary work, etc. Oral presentations, peer interviews, and group tasks can be used for this purpose The end-semester written examination will test all the areas targeted in the course – reading comprehension, vocabulary, grammar, composition, and oral communication. The proposed weightage for these sections in the end-semester exam is as follows:

- Reading Comprehension - 25 marks
- Vocabulary - 15 marks
- Grammar - 15 marks
- Written composition - 10 marks
- Oral communication - 10 marks

Keywords

English proficiency
Reading
Writing
Speaking
Listening
Pronunciation
Comprehension
Vocabulary
Syntax
Grammar
Composition
Conversation

COURSE CONTENT FOR SEMESTER III / IV

Building on the contents of the introductory semester, the focus in this semester is to further develop the language skills of the learners in all the core areas. The approach is to develop these skills in an integrated way through an intense engagement with the prescribed texts. In each unit, teachers are to eschew a narrow focus and ensure that all the activities in the prescribed sections are attempted by the learners

UNIT 6
Reading & Comprehending - II

This section involves reading and comprehending passages of greater length and complexity, using the prescribed texts that develop and test these skills through a variety of tasks: re-ordering, true / false sentence completion, fill in the blanks, short comprehension questions, etc.

Learners are to be encouraged to explore the texts listed below beyond the prescribed sections The comprehension of an unseen passage will be a part of the end-semester written examination

Prescribed readings:

A Foundation English Course for Undergraduates: Book II, Delhi: University of Delhi, 1992,pp. 1 - 7 Units 1 & 2 19 - 21 Unit 6 47 - 49 Unit 13 61 - 63 Unit 16 & 75 - 79 Unit 19
Everyday English 2, Delhi: Foundation Books, 2006, pp. 14 - 29 Units 3 - 5 91 - 101 Units 16 - 17 & 121 - 128 Unit 21

UNIT 7
Basic Grammar Rules - II

Questions, negatives, and question tags; conditionals; more on articles, prepositions, tenses, simple present, present continuous, present perfect, simple past, past continuous, past perfect, modals and linking words.

Relevant sections from all the recommended books are to be used in addition to the specific reading prescribed for this unit

Prescribed reading:
Developing Language Skills I Delhi: Manohar 1997 pp 183 - 186 & 209 - 216 Units 1 6 & 7 of 'Grammar'

UNIT 8
Conversing - II

Understanding word stress and features of connected speech; conversational formulae for getting and giving permission agreeing and disagreeing warning and persuading inviting suggesting accepting and refusing expressing likes and dislikes regulating speech and ending a conversation.

Prescribed readings:

English at the Workplace II, Delhi: Oxford University Press, 2007 pp. 10 - 13 Unit 3 & 38 –45 Unit 9
Developing Language Skills I, Delhi: Manohar, 1997, pp. 26 - 45 Units 6 - 10 of 'Oral Communication: Speech Patterns'

UNIT 9
Writing Skills - II

Writing short paragraphs of up to 150 words independently including describing people places events; giving directions; short application letters

Prescribed readings:

A Foundation English Course for Undergraduates: Workbook I, Delhi: Oxford University Press, 1991, pp. 32 - 63 Units VI - X

UNIT 10
Applying for a Job

Learning to present oneself at job interviews; writing simple job applications

Prescribed readings:

English at the Workplace, Delhi: Macmillan, 2006, pp. 67 - 75 Unit 11
Everyday English 2, Delhi: Foundation Books, 2006, pp. 121 - 128 Unit 21

Recommended readings:

A Foundation English Course for Undergraduates: Book II, Delhi: University of Delhi, 1992, pp 1 – 7 Units 1 & 2 19 – 21 Unit 6 47 – 49 Unit 13 61 – 63 Unit 16 & 75 – 79 Unit 19
Everyday English 2, Delhi: Foundation Books, 2006 pp 14 – 29 Units 3 – 591 – 101 Units 16 – 17 & 121 – 128 Unit 21
A Foundation English Course for Undergraduates: Workbook I Delhi: Oxford University Press 1991 pp 32 – 63 Units VI – X
Developing Language Skills I Delhi: Manohar 1997 pp 26 – 45 Units 6 – 10 of 'Oral Communication: Speech Patterns' 183 – 186 & 209 – 216 Units 1 6 & 7 of 'Grammar'

Internal Assessment:

Simple conversations in pairs; short oral presentations

End-semester evaluation pattern:

Reading comprehension	20 marks
Vocabulary	10 marks
Grammar	15 marks
Written composition	20 marks
Oral communication	10 marks

Teaching Plan

Teaching Learning Process

Since language skills can only be learnt and mastered through the use of the teaching-learning process, the course needs to be learner-centric The class time is to be taken up with hands-on activities by learners, involving reading aloud / silently, speaking, listening, and writing. Peer and group work should be used extensively. The teacher is to act as a facilitator, setting up and overseeing learner tasks and providing stimulus, encouragement, and corrective inputs as and when necessary. Teachers are also expected to source additional related material and activities pitched at an appropriate level of difficulty, to plug in gaps in the prescribed readings as well as to extend the knowledge of the learners and hone their skills

Teaching Plan for Semester III / IV

Week 1 – Introduction; *A Foundation English Course for Undergraduates: Book II*, pp. 1 – 7 Units 1 & 2
Week 2 – *Everyday English 2*, pp 14 – 29 Units 3 – 5
Week 3 – *A Foundation English Course for Undergraduates: Workbook I*, pp 32 – 36 Unit VI; *A Foundation English Course for Undergraduates: Book II*, pp 19 – 21 Unit 6

Week 4 – *A Foundation English Course for Undergraduates: Book II*, pp 47 – 49 Unit 13; *Developing Language Skills I*, pp 183 – 186 Unit 1 of 'Grammar'
Week 5 – *A Foundation English Course for Undergraduates: Book II*, pp 61 – 63 Unit 16 75 – 79 Unit 19
Week 6 – *Developing Language Skills I*, pp 209 – 216 Units 6 & 7 of 'Grammar'; Everyday English 2, pp 91 – 94 Unit 16
Week 7 – *A Foundation English Course for Undergraduates: Workbook I*, pp 37 – 42 Unit VII; *Everyday English 2*, pp 95 – 101 Unit 17
Week 8 – *A Foundation English Course for Undergraduates: Workbook I*, pp 43 – 47 Unit VIII; *Developing Language Skills I*, pp 26 – 31 Unit 6 of 'Oral Communication: Speech Patterns'
Week 9 – *A Foundation English Course for Undergraduates: Workbook I*, pp 48 – 51 Unit IX; *Developing Language Skills I*, pp 31 – 34 Unit 7 of 'Oral Communication: Speech Patterns'
Week 10 – *A Foundation English Course for Undergraduates: Workbook I*, pp 52 – 57 Unit X; *Developing Language Skills I*, pp 35 – 37 Unit 8 of 'Oral Communication: Speech Patterns'
Week 11 – *Developing Language Skills I*, pp 37 - 45 Units 9 – 10 of 'Oral Communication: Speech Patterns'

Week 12 – *English at the Workplace II*, pp 38 - 45 Unit 9
Week 13 – *English at the Workplace*, pp 67 - 75 Unit 11
Week 14 – *Everyday English 2*, pp 121 - 128 Unit 21

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Expressing concepts through writing	How to think critically and write with clarity	Writing essay length assignments
Demonstrating conceptual and textual understanding in tests and exams	Discussing exam questions and answering techniques	Class tests

Practical

The entire course is practical in nature. The prescribed readings are rich in tasks and activities that aim at developing essential language skills. Working their way through these tasks will give the learners hands-on practice in the use of these skills.

References

A Foundation English Course for Undergraduates: Reader I Delhi: Oxford University Press 1991
A Foundation English Course for Undergraduates: Workbook I Delhi: Oxford University Press 1991
Everyday English Delhi: Pearson 2005
Developing Language Skills I Delhi: Manohar 1997

Additional Resources:

English at the Workplace Delhi: Macmillan 2006

Assessment Methods

Since the class is conceived as learner-centric and built around tasks that require learners to actively use various language skills, formative assessment can and should be used extensively. The focus here could be on skills and activities that are harder to test in a written evaluation, such as speaking and listening skills, dictionary work, etc. Oral presentations, peer interviews, and group tasks can be used for this purpose The end-semester written examination will test all the areas targeted in the course – reading, comprehension, vocabulary, grammar, composition, and oral communication. The proposed weightage for these sections in the end-semester exam is as follows:

Reading Comprehension - 25 marks

- Vocabulary - 15 marks
- Grammar - 15 marks
- Written composition - 10 marks
- Oral communication - 10 marks

Keywords

English proficiency
Reading
Writing
Speaking
Listening
Pronunciation
Comprehension
Vocabulary
Syntax
Grammar
Composition
Conversational formulae

Committee Members

Jaspal Singh, PGDAV College **--** Coordinator(English Proficiency I & II)
Abhishek Bhaskar, Vivekananda College
Manoj Garg, ANDC
Pema Yolmo, Dyal Singh College
Tasneem Shahnaz, Sri Aurobindo College
Sachin N, Dyal Singh College

Members of B.A/B.Com. Programme Core Language Cluster Subcommittee

Sachin N, Dyal Singh College -- Coordinatore
Abhishek Bhaskar, Vivekananda College
Aneeta Rajendran, Gargi College
Hari Prasad, Zakir Husain Delhi College
Indira Prasad, Miranda House
Jaspal Singh, PGDAV College
Kuntal Tamang, Motilal Nehru College
Manoj Garg, ANDC
Mukti Sanyal, Bharati College

Neenu Kumar, Aditi Mahavidyalaya
Nidhi Bhandari, Kamla Nehru College
Nisha Singh, Bharati College
Nupur Mittal, SPM College
Pema Yolmo, Dyal Singh College
Rohith P, DDU College
Shivranjani Singh, Dyal Singh College
Tasneem Shahnaz, Sri Aurobindo College
Urvashi Vashisht, Gargi College

Working Group Members for Course Revision of SEC, DSE and GE papers of B.Sc (H) Biochemistry-2019

Type of paper	Semester	Name of paper	Member 1	Member 2	Member 3	Coordinator
Skill-Enhancement Elective Course	**III**	**Biochemical Techniques**	Meenakshi Kuhar	Rajni Jain	Sunita Singh	Prof. V.K Chaudhary
		Biostatistics	Nandita Narayanasamy	Jayita Thakur	Bhupinder Kumar	Dr Garima Khare
	IV	**Bioinformatics**	N. Latha	Radhika Gupta	Meenakshi Vacher	Dr Garima Khare
		Microbial Techniques	Renu Baweja	Prabha Arya	Meenakshi Vacher	Dr Amita Gupta
Discipline Specific Elective	**V**	**Nutritional Biochemistry**	Padamshri Mudgal	Archana Burman	Nandita Narayanasamy	Prof. Alo Nag
		Advanced Cell Biology	Sarita Nanda	Nitika Kaushal	Jayita Thakur	Prof D.P. Sarkar
		Microbiology	Renu Baweja	Prabha Arya	Shalini Sen	Dr Amita Gupta
	VI	**Molecular Basis of Infectious Disease**	Nitika Kaushal	Nalini Wali	Radhika Gupta	Dr Amita Gupta
		Plant Biochemistry	Nimisha Sinha	Vanshika Lumb	Rashmi Wardhan	Prof. Suman Kundu
		Research Methodology	Vandana Malhotra	Bhupinder Kumar	Taruna Arora	Prof. Suman Kundu
Generic Elective	**I**	**Biomolecules**	Neena R. Wadehra	Sadhna Jain	Leena Vig	Prof. D.P Sarkar
		***Techniques in Biochemistry**	Meenakshi Kuhar	Ravinder Verma	Anita Mangla	Dr. Garima Khare
	II	***Protein and Enzyme**	Anita Sondhi	Sunita Singh	Ravinder Verma	Prof. Suman Kundu
		***Techniques in Biochemistry**	Meenakshi Kuhar	Ravinder Verma	Anita Mangla	Dr Garima Khare
		***Biochemical Correlations of Disease**	Darshan Malik	Nalini Wali	Anita Goel	Prof. Alo Nag
	III	***Protein and Enzyme**	Anita Sondhi	Sunita Singh	Ravinder Verma	Prof. Suman Kundu
		Intermediary Metabolism	Sarika Yadav	Kameshwar Sharma	Neeraj Dohare	Dr Garima Khare
		Forensic Sciences	Nandita Narayanasamy	Sadhna Jain	Neeru Dhameja	Prof. Alo Nag
	IV	***Biochemical Correlations of Disease**	Darshan Malik	Nalini Wali	Anita Goel	Prof. Alo Nag
		Recombinant DNA Technology	Rashmi Wardhan	Vandana Malhotra	Vanshika Lumb	Prof. V.K. Chaudhary

*Papers to be offered twice in two different semesters

We also identified two students to be working committee members (2018 pass out). Their details need to be added to Dashboard as follows:

Sr No	Name of student	E-mail ID	Mobile No
1	Simran Motwani	simran199624@gmail.com	7838707980
2	Meenakshi Tyagi	Meenakshityagi100@gmail.com	8800782878

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

Shalini Sen <ssen@svc.ac.in>

Fwd: LOCF:DU, Login Credentials for LOCF

2 messages

Shalini Sen <shalinisen2@yahoo.co.in> Sat, Apr 6, 2019 at 3:59 PM
To: Shalini Sen <ssen@svc.ac.in>

Sent from my iPad

Begin forwarded message:

> **From:** "LOCF:DU Team" <ugcr2019@du.ac.in>
> **Date:** 5 April 2019 at 8:50:33 PM IST
> **To:** shalinisen2@yahoo.co.in
> **Subject: LOCF:DU, Login Credentials for LOCF**
> **Reply-To:** "LOCF:DU Team" <ugcr2019@du.ac.in>
>
> Dear Working Group Member,
>
> The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).
>
> You have been identified as a Working Group Member for the revision of the Course titled Genetic Engineering and Biotechnology Course Code BCH C-13 in Programme (CBCS) B.SC.(HONS.) BIOCHEMISTRY.
>
> Login URL: ugcr2019.du.ac.in
> Username: shalinisen2@yahoo.co.in
> Password: 2313
>
> Regards,
> Under-Graduate Curriculum Revision Committee-2019 University of Delhi

---

Shalini Sen <ssen@svc.ac.in> Wed, Mar 24, 2021 at 5:10 PM
To: shalinimehtasen@gmail.com

[Quoted text hidden]

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

Gmail

Shalini Sen <shalinimehtasen@gmail.com>

Fwd: LOCF:DU, Login Credentials for LOCF
1 message

Shalini Sen <ssen@svc.ac.in>
To: shalinimehtasen@gmail.com

Wed, Mar 24, 2021 at 4:30 P

---------- Forwarded message ---------
From: **LOCF:DU Team** <ugcr2019@du.ac.in>
Date: Wed, Mar 27, 2019 at 2:26 PM
Subject: LOCF:DU, Login Credentials for LOCF
To: Dr Shalini Sen <ssen@svc.ac.in>

Dear Dr Shalini Sen,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Fundamentals of Genetics Course Code BS C12 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

Login URL: ugcr2019.du.ac.in
Username: ssen@svc.ac.in
Password: 3234

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

10:33 47%

LOCF:DU, Login Credentials for LOCF

Inbox

LOCF:DU Team 15/4/2019

to me

Dear Dr Namita Nayyar,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Hormone Biochemistry Course Code BS DSE-4 in Programme (CBCS) B.SC.(HONS.) BIOLOGICAL SCIENCE.

Login URL: ugcr2019.du.ac.in
Username: nayyarnamita@gmail.com
Password: 6993

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

Reply | Reply all | Forward

2018-19 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

2017-18 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

B.A. (Honours) Sociology under CBCS

Contents

S.No.	Name of the Course	Convenors	
C 01	Introduction of Sociology I	Reema Bhatia, Bhawna Sharma, Ravindera K	
C 02	Sociology of India I	Nabanipa Bhattacharya, Vandana, Priya Ranjan	
C 03	Introduction of Sociology II	Reema Bhatia, Bhawna Sharma, Ravindera K	
C 04	Sociology of India II	Nabanipa Bhattacharya, Vandana, Priya Ranjan	
C 05	Political Sociology	Dr. Geetika Dey, Pravati, Srirupa Bhattacharya	
C 06	Sociology of Religion	Gopa Sabharwal, Charu, Archana	
C 07	Sociology of Gender	Mahima Verma, Gopi, Leki	
C 08	Economic Sociology	Pravati Dalva, Twinkle, Padma Priyadarhini	
C 09	Sociology of Kinship	Archana Prasad, Anjali, Charu	
C 10	Social Stratification	Rajyalakshmi, S.C. Mohapatra, Renny Thomas	
C 11	Sociological Thinkers I	Abhijeet Kundu, Urna, Rachel Philip	
C 12	Sociological Research Methods I	Charu Kala/Gopa Sabharwal, Binu	
C 13	Sociological Thinkers II	Abhijeet Kundu, Urna, Rachel Philip	
C 14	Sociological Research Methods II	Charu Kala/Gopa Sabharwal, Nupurnima	
	Discipline Specific Electives (DSE)		
DSE 01	Urban Sociology	Shalini Suryanarayan, Vandana, Sashwati	
DSE 02	Agrarian Sociology	Padma , Ravinder K, Ravi Nanadan	
DSE 03	Environmental Sociology	Padma, Arushi, Dhiren	
DSE 04	Sociology of Work	Geeta Sondhi, Rajyalakshmi, Srirupa	
DSE 05	Sociology of Health and Medicine	Sharmistha, Rachel, Ruby	
DSE 06	Indian Sociological Traditions	Archana Prasad, Rajyalakshmi, Nupurnima	
DSE 07	Visual Culture	Nivedita Ghosh, Leki,	

		Anasuya	
DSE 08	Reading Ethnographies	Vandana Madan, Anasuya, Ravi Nandan	
	Generic Electives (GE)		
GE 01	Indian Society: Images and Realities	Ravindra Kumar, Pouri, Urmi	
GE 02	Family and Intimacy	Anjali Bhatia,Anasuya, Padma	
GE 03	Rethinking Development	Priya Ranjan, Antasa, Ravindere K	
GE 04	Gender and Violence	Abhijeet Kundu, Sashwati, Sarbani, Kanika	
GE 05	Sociology of Social Movements	Geetika, Binu, Pranveer	
GE 06	Sociology of Education	Dhiren, Rachel, Sonia	
GE 07	Sociology of Media	Ritu Sharma, Anjali, Sayyed	
GE 08	Population and Society	Gopa Sabharwal, Reema, Priya Ranjan	
	Skill Enhancement Courses		
SEC 01	Reading, Writing and Reasoning for Sociology	Geetika, Kanika, Renny	
SEC 02	Techniques of Ethnographic Film Making	Nivedita Ghosh, Pouri, Madhulika	

B.A. (Program) Sociology under CBCS

Contents

S.No.	Name of the Course	Convenors	
C 01	Introduction of Sociology	Anurita Jalan, Kulbir, Anuragini	
C 02	Sociology of India	Tanushree Raha, Dhiren, Geeta	
C 03	Sociological Theories	Lakshmi B, Anuraag Singh, Buta Singh,	
C 04	Methods of Sociological Enquiry	Lakshmi B, Amrita, Brij Mohan	
	Discipline Specific Electives (DSE)		
DSE 01	Religion and society	S.C. Mahapatra, Pranveer, Carolyin	

2017-18 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING

DSE 02	Marriage, Family and Kinship	Anurita Jalan, Archna, Aruna	
DSE 03	Social Stratification	S.C. Mahapatra, Aruna, Brij Mohan	
DSE 04	Gender and Sexuality	Leki, Antasa, Shaswati	
	Generic Electives (GE)		
GE 01	Polity and society in India	Brij Mohan, Anuraagini, Sushma	
GE 02	Economy and Society	Sushma, Pravati, Bhawana	
	Skill Enhancement Courses		
SEC 01	Techniques of Social Research	Amrita Sastry, Rashi, Anuraag Singh	
SEC 02	Gender Sensitization	Kulbir Kaur, Urna, Amrita	
SEC 03	Society through the Visual	Sushma, Carolyine, Sarbani	
SEC 04	Theory and Practice of Development	Sushma, Jessi, Anuraag Singh	

Gmail

Padma Priyadarshini <padmauw@gmail.com>

Fw: LOCF

padma priyadarshini <padma_priyadarshini@rediffmail.com> Mon, Mar 29, 2021 at 7:33 AM
To: padmauw <padmauw@gmail.com>

From: Rakhi Singh <sociodsephd2013@gmail.com>
Sent: Wed, 27 Mar 2019 14:36:38
To: Reema Bhatia <reema.bhatia@mirandahouse.ac.in>, Avantika Berwa <avantika.berwa@gmail.com>, anasua.chatterjee@mirandahouse.ac.in, Shivani Rajput <shivanilsr.rajput@gmail.com>, Binu Sundas <binusundas@gmail.com>, kamminthang@gmail.com, geetajsodhi@yahoo.com, nabanipab@svc.ac.in, subas_mopt@yahoo.com, abhijit242003 <abhijit242003@gmail.com>, padma_priyadarshini@rediffmail.com, urmi bhattacharyya <urmi.jnu@gmail.com>, Antasa Vairagya <antasa.vairagya@gmail.com>, Nupurnima Yadav <nupurnima.yadav@gmail.com>, achla tandon <Achlatandon10@gmail.com>, shalinisurya@rediffmail.com, Gitika De <de.gitika@gmail.com>, ravigzp@gmail.com, twinkle Pal <twinklepal@gmail.com>, Aarushie Sharma <aarushie@gmail.com>, premchand_saxena@yahoo.com, Anurita Jalan <jalan_anurita@yahoo.co.in>, gopi.edit@gmail.com, mkshank2001@yahoo.co.in, Pratisha Borborah <pratisha23.jnu@gmail.com>, Aruna Grover <arunagrover@gmail.com>, rashi.bhargava16@gmail.com, Madhulika Sonkar <madhulika.sonkar@gmail.com>, Ruby Bhardwaj <bhardwaj_ruby@yahoo.com>, Vandana Madan <vandana.madan@gmail.com>, charu.kala@rediffmail.com, rajyalakshmi rama <drrajya@yahoo.co.in>, kanika.kakar@rediffmail.com, Pouriangthanliu <areanga8@gmail.com>, Suraj B <criticalsun@gmail.com>, Tanusree Kundu <trahakundu@gmail.com>, amrita sastry <amritasastry@gmail.com>, Mahima Varma <mahimasocio@gmail.com>, Nivedita Ghosh <ghosh.nivedita@hotmail.com>, Anuradha Sharma <anuradha.s0909@gmail.com>, Renny Thomas <rennyjnu@gmail.com>, saumya malviya <saumya.najim@gmail.com>, Sarbani Sharma <sarbanisharma@gmail.com>, Anuragini Shreeya <anuragini88@gmail.com>, anjalibhatia6@gmail.com, Bhawana JHA <Bhawana.s.jha@gmail.com>, Saswati Bhattacharya <saswati.bhattacharya@gmail.com>, Dhiren Kumar <d.kumarjnu@gmail.com>, rkarnena@gmail.com, leki thungon <lekithungon@gmail.com>, "banojyotsna ..." <banojyotsna@gmail.com>, Srirupa Bhattacharya <srirupa.online@gmail.com>, Archana Prasad <archanaprasad2310@gmail.com>, Pravati Dalua <pravati.jnu@gmail.com>, Urna Dutta <urna.dutta@gmail.com>, senoritaritu@yahoo.com, Brij Mohan <brijm26@gmail.com>, Sharmistha Mallick <sharmistha.mallick@gmail.com>, Pran veer singh <pran084@gmail.com>, Sonia Kumari <ink.sonia@gmail.com>, vikrant kumar <vikrantjnu@gmail.com>, anurag singh <anuragsingh060186@gmail.com>, Buta Singh <butasingh101@gmail.com>, shashjnu@rediffmail.com, Kulbir Kaur <kaur.kulbir@gmail.com>, Caroline Patton <carolineptn6@gmail.com>, pattonrenthunglo@gmail.com, Nirdosh Kumar <chandelnirdosh@gmail.com>, lakshmi_6387@yahoo.co.in, sushma yadav <Sushma.k2003@gmail.com>, Rahul Pandey <rahulpandey86@gmail.com>, priyaranjanmuni@gmail.com, mohd sayeed <mohd.sayeed@gmail.com>, Rachel Philip <p.s.rachel@gmail.com>, Devika Mittal <devikamittal31@gmail.com>, jyoti gupta <gupta_jyotee@yahoo.co.in>
Cc: roma chatterji <roma.chatterji0@gmail.com>, Vikramendra Bardhan <bardhan.vikramendra@gmail.com>
Subject: LOCF

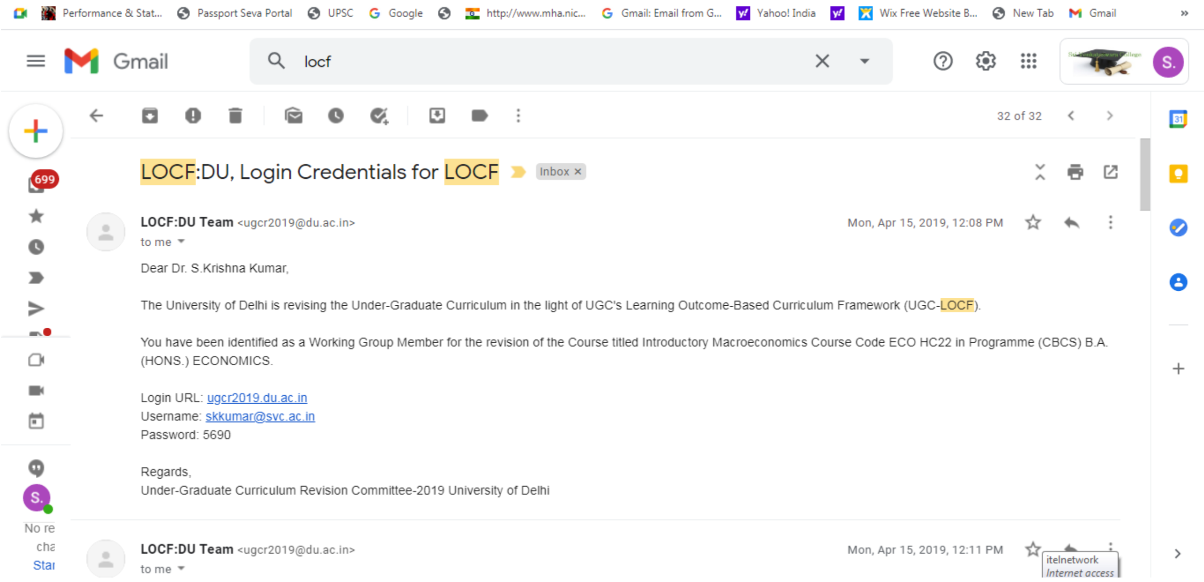
Dear College Teachers,

Working Group for Introduction to LOCF BA (Hons) Ruby Bharadwaj (Convenor), Anjali Bhatia and Leki Thungan.
Working Group for BA (Prog.) Manisha Verma (Convenor) Kulbir Kaur and Urna Dutta. (In Addition Two List)

Thanks,
Roma Chatterji

LOCF_BA_H__BA_P__2019.doc
67K

2017-18 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING


LOCF:DU, Login Credentials for LOCF

LOCF:DU Team <ugcr2019@du.ac.in> Mon, Apr 15, 2019, 12:08 PM
to me

Dear Dr. S.Krishna Kumar,

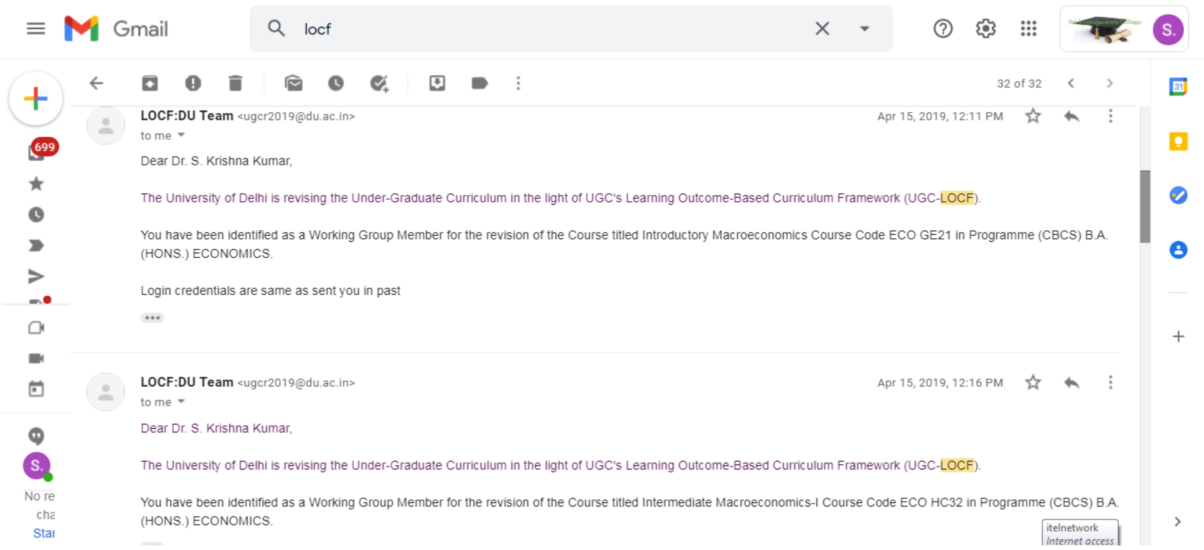
The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Introductory Macroeconomics Course Code ECO HC22 in Programme (CBCS) B.A. (HONS.) ECONOMICS.

Login URL: ugcr2019.du.ac.in
Username: skkumar@svc.ac.in
Password: 5690

Regards,
Under-Graduate Curriculum Revision Committee-2019 University of Delhi

LOCF:DU Team <ugcr2019@du.ac.in> Mon, Apr 15, 2019, 12:11 PM
to me


LOCF:DU Team <ugcr2019@du.ac.in> Apr 15, 2019, 12:11 PM
to me

Dear Dr. S. Krishna Kumar,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Introductory Macroeconomics Course Code ECO GE21 in Programme (CBCS) B.A. (HONS.) ECONOMICS.

Login credentials are same as sent you in past

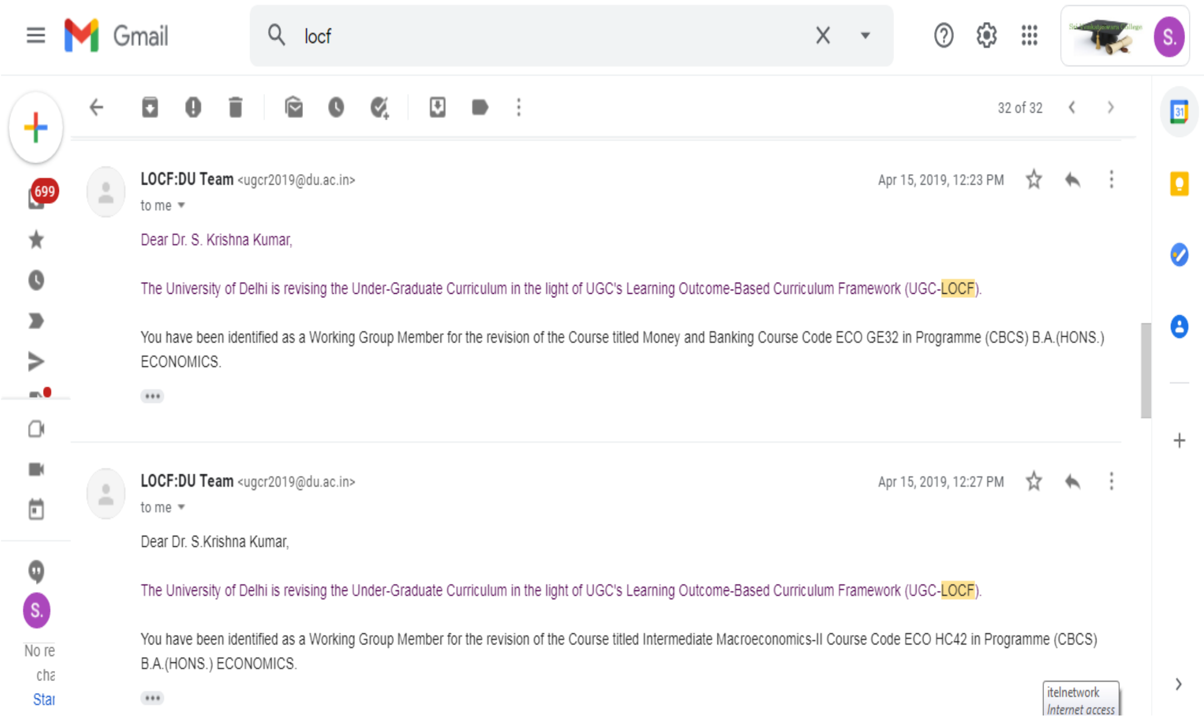
LOCF:DU Team <ugcr2019@du.ac.in> Apr 15, 2019, 12:16 PM
to me

Dear Dr. S. Krishna Kumar,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Intermediate Macroeconomics-I Course Code ECO HC32 in Programme (CBCS) B.A. (HONS.) ECONOMICS.

2017-18 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING



Gmail

locf

32 of 32

LOCF:DU Team <ugcr2019@du.ac.in> Apr 15, 2019, 12:23 PM

to me

Dear Dr. S. Krishna Kumar,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Money and Banking Course Code ECO GE32 in Programme (CBCS) B.A.(HONS.) ECONOMICS.

LOCF:DU Team <ugcr2019@du.ac.in> Apr 15, 2019, 12:27 PM

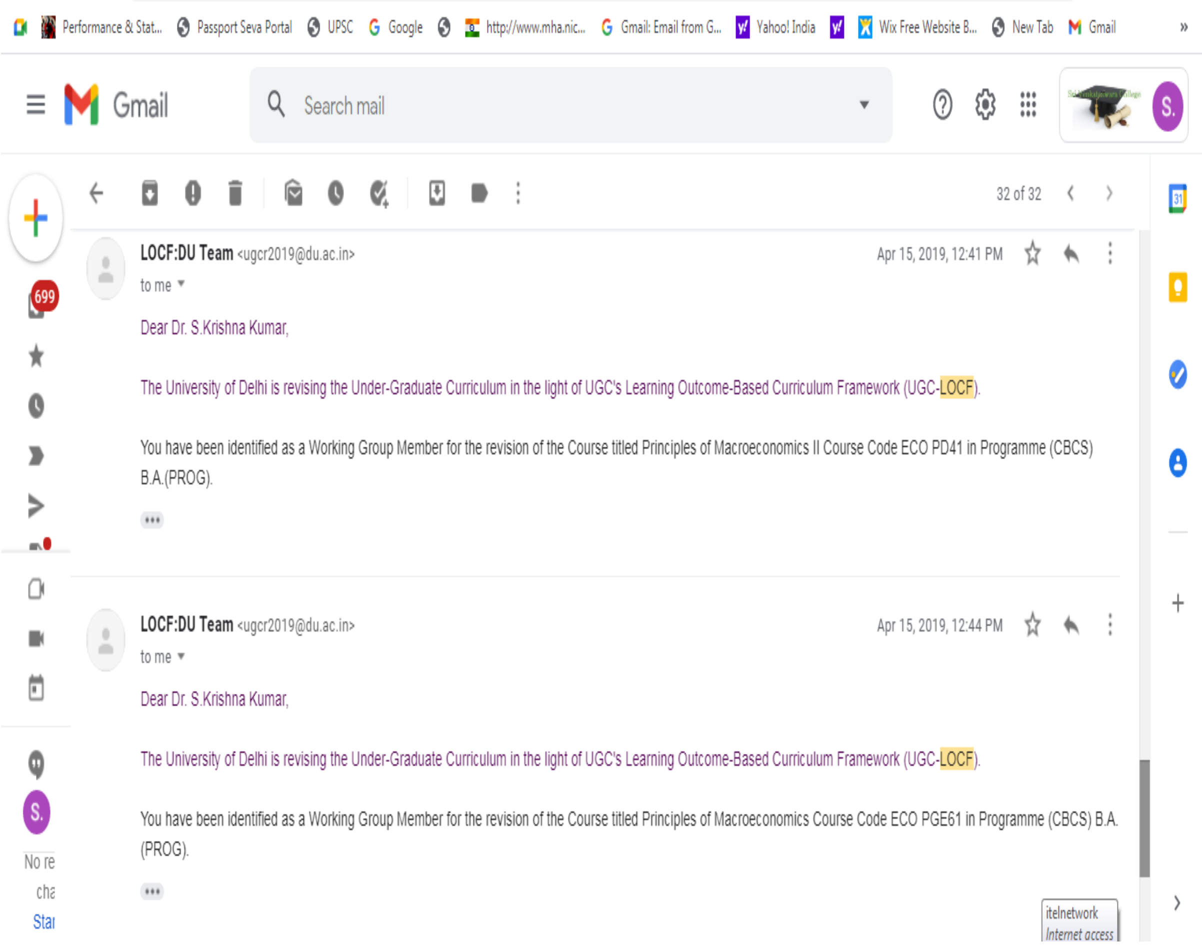
to me

Dear Dr. S.Krishna Kumar,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Intermediate Macroeconomics-II Course Code ECO HC42 in Programme (CBCS) B.A.(HONS.) ECONOMICS.

2017-18 PARTICIPATION OF TEACHERS IN BOS, COMMITTEE OF COURSES, COURSE REVISION, QUESTION PAPER SETTING



LOCF:DU Team <ugcr2019@du.ac.in> Apr 15, 2019, 12:41 PM

to me

Dear Dr. S.Krishna Kumar,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Principles of Macroeconomics II Course Code ECO PD41 in Programme (CBCS) B.A.(PROG).

LOCF:DU Team <ugcr2019@du.ac.in> Apr 15, 2019, 12:44 PM

to me

Dear Dr. S.Krishna Kumar,

The University of Delhi is revising the Under-Graduate Curriculum in the light of UGC's Learning Outcome-Based Curriculum Framework (UGC-LOCF).

You have been identified as a Working Group Member for the revision of the Course titled Principles of Macroeconomics Course Code ECO PGE61 in Programme (CBCS) B.A. (PROG).

दिल्लीविश्वविद्यालय

UNIVERSITY OF DELHI

Bachelor of Science (Hons) Botany

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Applicable for students registered with Regular Colleges, Non Collegiate Women's Education Board and School of Open Learning

List of Contents

Page No.

Preamble

The objective of anyprogramme at Higher Education Institute is to prepare their students for the society at large. The University of Delhi envisions all its programmes in the best interest of their students and in this endeavour it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes.

The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the programme of their choice. The Under-Graduate Programmes will prepare the students for both, academia and employability.

Each programme vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programmes also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each programme prepares students for sustainability and life-long learning.

The new curriculum of B.Sc. (Hons) Botany offer essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

The University of Delhi hopes the LOCF approach of the B.Sc. (Hons) Botany will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

B.Sc.(HONS.) BOTANY (CBCS)

INTRODUCTION

The B.Sc. - Botany honours programme is designed to equip students with essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

Choice Based Credit System:

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed.

Outline of Choice Based Credit System:

1. Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.
2. Elective Course: Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.
2.1 Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).
2.2 Dissertation/Project: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.
2.3 Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

3. Ability Enhancement Courses (AEC)/Competency Improvement Courses/Skill Development Courses/Foundation Course: The Ability Enhancement (AE) Courses may be of two kinds: AE Compulsory Course (AECC) and AE Elective Course (AEEC). "AECC" courses are the courses based upon the content that leads to Knowledge enhancement. They ((i) Environmental Science, (ii) English/MIL Communication) are mandatory for all disciplines. AEEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.

3.1 AE Compulsory Course (AECC): Environmental Science, English Communication/MIL Communication.

3.2 AE Elective Course (AEEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

Project work/Dissertation is considered as a special course involving application of knowledge in solving / analyzing /exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

LEARNING OUTCOME BASED CURRICULUM FRAMEWORK

Nature and extent of the B.Sc Honours Botany Programme

Content: Botany is the broad discipline encompassing various subjects involved with the study of plants. TheB.Sc Botany (H) Programme imparts knowledge on various fields of plant biology through teaching, interactions and practical classes. Present trend has been shifted to frontier areas of plant sciences at the cost of traditional botany. There is need to maintain a balance of the traditional botany and modern science and applied approach. This syllabus has been drafted to enable the learners to prepare them for future employment in various fields including academics as well as competitive exams. Students would gain wide knowledge as follow:

1. Diversity of plants and microbes their habitat, morphology, and reproduction.
2. Genetics and molecular biology of plants
3. Fungi and disease causing microbes and fungi
4. Economic value of plants and their use in Biotechnology

Biodiversity generally refers to the variety and variability of life on earth. Earth is a 'green' planet due to the presence of plants. Plants are relevant to humans as they provide us with food, shelter, clothing, energy, health, aesthetic beauty, environment and even economy. This paper is relevant to ALL students. Introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi and to various plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms) and information on the Ecological and Economic Importance of Microbes, Fungi and various plant groups to enable students understand and appreciate relevance of Microbes and Plants to environment and human well-being. Insight into the line of

Plant Evolution on Earth and the consequent Biodiversity is instrumental in creating Awareness on the threats to biodiversity and sensitize young minds towards the Biodiversity Conservation for sustainable development. Combination of Theoretical and Practical components will provide comprehensive information and insight into the

1. Fascinating world of Microbes and Plants.
2. Hands on Training will help students learn use of microscope, mounting, section-cutting and staining techniques for the study of plant materials.
3. Making Drawings in Practical Records will enhance understanding morphological and structural details and related functional aspects in diverse plant groups.
4. Use of Illustrations, Photographs, Charts, Permanent Slides, Museum and Herbarium Specimens along with ICT Methods will provide an interesting insight into the beautiful world of microbes and plants.
5. Scope of Biodiversity includes Medicinal field, Industry, Agriculture, Research and Study, Job Opportunities and Environmental Conservation. This paper is both informative and interesting and will enable students to learn about Biodiversity not only as a plant or nature lover, but also for higher academic pursuits, particularly in the field of Biological Sciences, Environment and Biodiversity Conservation.
6. The relationship between the properties of macromolecules, their cellular activities and biological responses.
7. Understanding of Cell metabolism, chemical composition, physiochemical and functional organization of organelles.
8. Contemporary approaches in modern cell and molecular biology.
9. Understand how plant sciences and microbiology is applied in manufacturing of industrial products
10. Know about design of bioreactors, factors affecting growth and production
11. Comprehend the techniques and the underlying principles in upstream and down- stream processing
12. Learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection
13. Understand various biogeochemical cycles – Carbon and Nitrogen, and microbes involved
14. Understand the basic principles of organism and environment interation and application of the same in solving environmental problems – waste water treatment and bioremediation
15. Learn the basic concepts, principles and processes in plant biotechnology.
16. Have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.
17. Use basic biotechnological techniques to explore molecular biology of plants Explain how biotechnology is used to for plant improvement and discuss the biosefty concern and ethical issue of that use.

Aims of Bachelor's degree programme in (CBCS) B.SC.(HONS.) BOTANY

Content: 1. Provide an introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi, including diverse plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms).

2. To enable students to understand and appreciate the relevance of Microbes and Plants to environment (ecological significance) and human well-being (economic importance).

3. Develop an understandingof Evolution of Plant formsand the consequent Biodiversity. These are instrumental in creating awareness on the threats to biodiversity and sensitizestudents towards the Conservation of Biodiversity for sustainable development.

4. To study the organization of cell, cell organelles and biomolecules (i.e protein, carbohydrate, lipid and nucleic acid) to gain knowledge on the activities in which the diverse macro molecules and microscopic structures inhabiting the cellular world of life are engaged. This will enable the students to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life.

5. To introduce students to application of microbes in Industrial production and Environmental remediation strategies.

6. New knowledge and widening of the knowledge acquired in by handling of classical and modern plant biotechnology processes, including tissue culture for healthy plants, plants with improved characteristics.

7. To explore the natural genetic variation in plants and to understand how diverse factors (at the cellular level) contribute to the expression of genotypes and hence to phenotypic variation.

8. Understanding of biotechnological processes such as recombinant DNA technology and its applicative value in pharmaceuticals (vaccines, antibodies, antibiotics etc.), food industry (transgenic crops with improved qualities (nutraceuticals, industrial enzymes etc.), agriculture (biotic and abiotic stress tolerant plants, disease and pest resistant plants, improved horticultural varieties etc.), ecology (plants role in bioremediation). This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture.

9. In the laboratory classes, students will perform some of the techniques currently used to generate information and detect genetic variation.

10. Understanding of plant classification systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various plants groups.

11. Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as human livelihood support system and the use of transgenic technologies for basic and applied research in plants.

12. Understanding of various life forms of plants, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology and use of bioinformatics tools and databases and in the application of statistics to biological data

13. To provide new information, enhance core competency and discovery/inquiry based learning of learners. A botany graduate would be competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.

14. To make students aware of most basic domain-independent knowledge, including critical thinking and communication.

15. To enable the graduate to prepare for national and International competitive examinations for employment.

GRADUATE ATTRIBUTES IN SUBJECT

Disciplinary knowledge

The B.Sc. - Botany programme enables the students in gaining knowledge and technical skills to study plants in a holistic manner. Students would get training in various disciplines of plant sciences using a combination of core and elective papers with significant inter-disciplinary components. Students would be exposed to basic and advanced knowledge that are currently used in the study of plant life forms, adaptation, evolution, classification, ultrastructure and various processes in the plant system and interaction of plants with other organisms and with the ecosystem. Knowledge of use of plants in biotechnology, their economic value and their social and environmental significance would be gained by the students.

Scientific reasoning

In addition to academic acquaintance and training in the various fields of plant sciences. Students would also get training in application of the subject, critical thinking, reasoning and analytical skills, effective communication, laboratory safety, and sensitivity to environment and sustainable living.

Critical thinking

The course enhance the skill of thinking about the application of the biology

Disciplinary knowledge

The programme also has a strong interdisciplinary component. Emphasis is given on the experimental learning through hands-on laboratory exercises, field trips and assignments. Current thrust areas of teaching provide students with substantial exposure and skills in plant biology.

Critical thinking

Learning of the basic concepts, principles and processes in plant biology and have the ability of explanation of principles and usage of the acquired knowledge in applied botany. An increased understanding of fundamental concepts and their applications of scientific principles is expected in the student. Students will become critical thinker and acquire problem solving capabilities. They are expected to know basics of cognitive biases, mental models, logical fallacies, scientific methodology and constructing cogent scientific arguments.

Problem solving

The B.Sc. - Botany programme is formed to gain knowledge and technical skills to study plants in a holistic manner. Students would get training in various disciplines of plant sciences using a combination of core and elective papers with significant inter-disciplinary components.

Analytical reasoning

The student would develop a skill to analyse the knowledge of the subject and think in a multi-directional way to solve the problem and to gain benefit in a sustainable manner. They would be able to think about the use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants. The students will be able to demonstrate the knowledge in understanding research and addressing practical problems. Student will learn the application of various scientific methods to address different questions by formulating the hypothesis, data collection and critically analyze the data to decipher the degree to which their scientific work supports their hypothesis.

Reflective thinking

The structure and content of the course enables students to reflect on the learnings from different courses and integrate the same for a problem solving approach. They would be capable of correlating various concepts applicable to diverse situations and phenomenon.

Multicultural competence

Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.

Lifelong learning

The subject of botany the applied theoretically and practically applied in day today life.The successful students will be able to learn the basic concepts, principles and processes in plant biology. The have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications. Use basic biology techniques to explore molecular biology of plants

Self-directed learning

The programme also has a strong interdisciplinary component. Emphasis is on experiential learning through hands-on laboratory exercises, field trips and assignments. Current thrust areas of teaching provide students with substantial exposure and skills in plant biology.

Communication Skills

The students will develop a confidence on gaining the knowledge and skill after this course and they will be able to effectively communicate their views, present their work and impress the audience. Students are expected to possess a standard of communication skills expected from a science graduate in the country. They are expected to read and understand documents with in-depth analyses and logical arguments. Graduates are expected to be well-versed in speaking and communicating their idea/finding/concepts to a wider audience

Research-related skills

This course provides wide interdisciplinary knowledge and stimulates the students to think beyond the course knowledge, apply this knowledge for solving the environmental problems, efficient use of resources by designing novel and innovativeexperiments. . Students are expected to be aware about activities in the natural surroundings to awaken their curiosity. They are expected to design a scientific experiment through statistical hypothesis testing and reasoning.

Cooperation/Team work

The students would learn team work, division of the work and the corporate life of the academics. They are expected to be team players, with productive cooperation involving members from diverse socio-cultural backgrounds.

Information/digital literacy

The students would learn the use of the new technologies used in learning biology, digital platforms for fast transfer of information. Students will acquire digital skills and integrate the fundamental concepts with modern tools.

Moral and ethical awareness/reasoning

Besides the theoretical knowledge, the student is acquainted with moral and ethical duties, an awareness towards the conservation of nature and natural resources. Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses. Learners are expected to be responsible citizen and be aware of moral and ethical duties. They are expected to define their core ethical virtues good enough to distinguish what construes as illegal and criminal under Indian constitution. Learners should know academic and research ethics, Benefit Sharing, Plagiarism, Scientific Misconduct etc.

Leadership readiness/qualities

The vast and deep knowledge of the subject, analytical and scientific reasoning, effective communication and problem solving task develop special qualities in a person to attract and influence the audience, which would be gained after the completion of this course. Students are expected to be familiar with decision making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become responsible citizens and charismatic inspiring leader.

QUALIFICATION DESCRIPTORS

For a graduate student in Botany (Honours) the qualification descriptorsmay include following:
(i) To show a systematic, extensive, coherent knowledge and understanding of academic subjects and their applications, including critical understanding of the established theories, principles and concepts of a number of advanced and emerging issues in the field of Botany;
(ii) To gain knowledge to produce professionals in the field of plant sciences in research and development, academics (teaching in Schools, Colleges and University), government and public services e.g. conservationist, plant explorer, ecologist, horticulturist, plant biochemist, genetics,

nursery manager, molecular biologist, plant pathologist, taxonomist, farming consultant and environmental consultant. Further application of knowledge can enhance productivity of several economically important products. Knowledge of plant sciences is also necessary for the development and management of forests, parks, wastelands and sea wealth
(iii) Display skills and ability to use knowledge efficiently in areas related to specializations and current updates in the subject.
(iv) Provide knowledge about plants, current research, scholarly and professional literature of advanced learning areas of plant sciences
(v) Use knowledge understanding and skills for critical assessment of wide range of ideas and problems in the field of Botany
(vi) Communicate the outcomes of studies in the academic field of Botany through print and digital media.
(vii) Apply one's knowledge and understanding of Botany to new/unfamiliar contexts and to identify problems and solutions in daily life
(viii) Design and apply the knowledge of plant sciences in identifying the problems which can be solved through the use of plants
(ix) To think of adopting expertise in plant structure, functions and solve the problems of environment, ecology, sustainable development and enhancing productivity.
(x) Concept and significance of sustainable development and use of the plant resources

PROGRAMME LEARNING OUTCOME

The course learning outcomes are aligned with program learning outcomes but these are specific-to-specific courses offered in a program. The course level learning shall be reflected as program level learning. The core courses shall be the backbone of this framework whereas discipline electives, generic electives and skill enhancement courses would add academic excellence in the subject together with multi-dimensional and multidisciplinary approach.

1. Understanding of plant classification systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various life-forms. Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.

2. Understanding of various life forms of plants, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology and use of bioinformatics tools and databases and the application of statistics to biological data.

STRUCTURE OF B.SC. HONOURS BOTANY PROGRAMME UNDER CBCS

Part	Year	Semester (July to November)	Semester (January to May)
Part – I	First Year	Semester I	Semester II
Part – II	Second Year	Semester III	Semester IV
Part – III	Third Year	Semester V	Semester VI

Core Courses

1. Microbiology and Phycology
2. Biomolecules and Cell Biology
3. Mycology and Phytopathology
4. Archegoniatae
5. Anatomy of Angiosperms
6. Economic Botany
7. Genetics
8. Molecular Biology
9. Ecology
10. Plant Systematics
11. Reproductive Biology of Angiosperms
12. Plant Physiology
13. Plant Metabolism
14. Plant Biotechnology

Discipline Specific Electives	
Semester-V	DSE-1. Analytical Techniques in Plant Sciences DSE-2. Biostatistics DSE-3. Natural Resource Management
Semester-VI	DSE-4. Industrial and Environmental Microbiology DSE-5. Bioinformatics DSC-6. Plant Breeding
Generic Electives (Four) Offered to the students of other Departments	
Semester –I GE-I	GE-I (Any one) 1. Biodiversity (Microbes, Algae, Fungi and Archegoniatae) 2. Plant Anatomy and Embryology
Semester –II GE-II	GE-II 3. Plant Ecology and Taxonomy
Semester –III GE-III	GE-III (Any one) 4. Plant Physiology and Metabolism 5. Environmental Biotechnology
Semester –IV GE-IV	GE-IV : 6. Economic Botany and Biotechnology
Skill Enhancement Cources: Elective	
Semester-III	1. Ethnobotany 2. Intellectual Property Rights 3. Plant Diversity and Human Welfare 4. Floriculture
Semester-IV	5. Biofertilizers 6. Medicinal Botany 7. Mushroom Culture and Technology 8. Nursery and Gardening
Ability Enhancement Compulsory Course (AEC).	
AEC-1. English/MIL Communication AEC-2. Environmental Science	

COURSE CREDIT SCHEME – CONSOLIDATED

Course	*Credits	
	Theory+ Practical	Theory + Tutorial
I. Core Course		
(14 Papers)	14X4= 56	14X5=70
Core Course Practical / Tutorial*		
(14 Papers)	14X2=28	14X1=14
II. Elective Course		
(8 Papers)		
A.1. Discipline Specific Elective	4X4=16	4X5=20
(4 Papers)		
A.2. Discipline Specific Elective Practical/ Tutorial*	4 X 2=8	4X1=4
(4 Papers)		
B.1. Generic Elective/ Interdisciplinary	4X4=16	4X5=20
(4 Papers)		
B.2. Generic Elective Practical/ Tutorial*	4 X 2=8	4X1=4
(4 Papers)		

- **Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester**

III. Ability Enhancement Courses		
1. **Ability Enhancement Compulsory**		
(2 Papers of 2 credit each)	2 X 2=4	2 X 2=4
Environmental Science		
English/MIL Communication		
2. **Ability Enhancement Elective** (Skill Based)		
(Minimum 2)	2 X 2=4	2 X 2=4
(2 Papers of 2 credit each)		
Total credit	**140**	**140**

Institute should evolve a system/policy about ECA/ General Interest/Hobby/Sports/NCC/NSS/related courses on its own.

*** wherever there is a practical there will be no tutorial and vice-versa**

Semester wise Distribution of Courses

Semester	Core Course(14)	Ability Enhancement Compulsory Course (AEC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective: (DSE) (4)	Generic Elective: (GE) (4)
I	1.Microbiology and Phycology 2.Biomolecules and Cell Biology	English/MIL Communication/ Environmental Science			GE-1 (Any one) 1.Biodiversity (Microbes, Fungi, Algae, and Archegoniatae) 2.Plant Anatomy and Embryology
II	3. Mycology and Phytopathology 4. Archegoniatae	English/MIL Communication/ Environmental Science			GE-II 3.Plant Ecology and Taxonomy
III	5. Anatomy of Angiosperms 6. Economic Botany 7. Genetics		SEC-I (Any one) 1. Ethnobotany/ 2. Intellectual Property Rights 3.Plant Diversity and Human Welfare 4. Floriculture		GE-III (Any one) 4.Plant Physiology and Metabolism 5.Environmental Biotechnology
IV	8. Molecular Biology 9. Ecology 10.Plant Systematics		SEC-II (Any one) 5. Biofertilizers 6. Medicinal Botany 7. Mushroom Culture and Technology 8. Nursery and Gardening		GE-IV (Any one) 6.Economic Botany and Biotechnology
V	11.Reproductive Biology of Angiosperms 12.Plant Physiology			DSE-I 1.Analytical Techniques in Plant Sciences DSE-II (any one) 2. Biostatistics 3.Natural Resource Management	
VI	13.Plant Metabolism 14.Plant Biotechnology			DSE-III 4.Industrial and Environmental Microbiology DSE-IV 5.Bioinformatics 6. Plant Breeding	

Course wise assigned credits:

SEMESTER	COURSE OPTED	COURSE: NAME	Credits
I	Ability Enhancement Compulsory Course-I	English /MIL Communications/ Environmental Science	2
	Core Course-I	Microbiology and Phycology	4
	Core Course-I **Practical**	Microbiology and Phycology- Practical	2
	Core Course-II	Biomolecules and Cell Biology	4
	Core Course-II **Practical**	Biomolecules and Cell Biology-Practical	2
	Generic Elective-I	GE-I (Any one) 1.Biodiversity (Microbes, Algae, Fungi and Archegoniates) 2. Plant Anatomy and Embryology	4
	Generic Elective-I **Practical/Tutorial**	GE-I- Practical	2
II	Ability Enhancement Compulsory Course-II	English /MIL Communications/Environmental Science	2
	Core Course-III	Mycology and Phytopathology	4
	Core Course-III **Practical**	Mycology and Phytopathology- Practical	2
	Core Course-IV	Archegoniatae	4
	Core Course-IV Practical	Archegoniatae- Practical	2
	Generic Elective-II	GE-II 3. Plant Ecology and Taxonomy	4
	Generic Elective-II **Practical**	GE-II – Practical	2
III	Core Course-V	Anatomy of Angiosperms	4
	Core Course-V **Practical**	Anatomy of Angiosperms- Practical	2
	Core Course-VI	Economic Botany	4
	Core Course-VI **Practical**	Economic Botany –Practical	2
	Core Course-VII	Genetics	4
	Core Course-VII **Practical**	Genetics-Practical	2
	Skill Enhancement Course-I	SEC-I (Any one) 1. Ethnobotany 2. Intellectual Property Rights	2
	Generic Elective-III	GE-III (Any one) 4. Plant Physiology and Metabolism 5. Environmental Biotechnology	4
	Generic Elective-III **Practical**	GE-III -Practical	2
IV	Core Course-VIII	Molecular Biology	4
	Core Course-VIII **Practical**	Molecular Biology – Practical	2

	Core Course-IX	Ecology	4
	Core Course-IX **Practical**	Ecology – Practical	2
	Core Course-X	Plant Systematics	4
	Core Course-X **Practical**	Plant Systematics- Practical	2
	Skill Enhancement Course- II	SEC-II (Any one) 3. Biofertilizers 4.Medicinal Botany	2
	Generic Elective-IV	GE-IV Economic Botany and Biotechnology	4
	Generic Elective-IV **Practical**	GE-IV - Practical	2
V	Core Course-XI	Reproductive Biology of Angiosperms	4
	Core Course-XI **Practical**	Reproductive Biology of Angiosperms - Practical	2
	Core Course-XII	Plant Physiology	4
	Core Course-XII **Practical**	Plant Physiology- Practical	2
	Discipline Specific Elective-I	DSE-I Analytical Techniques in Plant Science	4
	Discipline Specific Elective-I **Practical**	DSE-I- Practical	2
	Discipline Specific Elective-II	DSE-II Biostatistics	4
	Discipline Specific Elective-II **Practical/Tutorial**	DSE-II – Practical	2
VI	Core Course-XIII	Plant Metabolism	4
	Core Course-XIII Practical/Tutorial	Plant Metabolism- Practical	2
	Core Course-XIV	Plant Biotechnology	4
	Core Course-XIV **Practical/ Tutorial**	Plant Biotechnology- Practical	2
	Discipline Specific Elective-III	DSE-III Industrial and Environmental Microbiology	4
	Discipline Specific Elective-III **Practical**	DSE-III- Practical	2
	Discipline Specific Elective-IV	DSE-IV Bioinformatics	4
	Discipline Specific Elective-IV **Practical/Tutorial**	DSE-IV Bioinformatics- Practical	2
Total			140

COURSES FOR PROGRAMME

COURSE LEARNING OBJECTIVES

The progamme is designed to equip students with essential knowledge and technical skills to study plants and related subjects in a holistic manner. hteh main aim is to train the learners in all areas of plant biology using appropriate combinations of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

COURSE LEARNING OUTCOMES

1. Students will be able to understand and explain different specializations of Botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, cell and molecular biology of plants.

2. Students will be trained in various analytical techniques of plant biology, use of plants as industrial resources or as support system for human livelihood and will be well versed with the use of transgenic technologies for both basic and applied research in plants.

3. Students will be able to identify various life forms of plants, design and execute experiments related to basic studies on evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology. Students are also familiarized with the use of bioinformatics tools and databases and in the application of statistics to biological data.

4 Students will acquire core competency in the subject Botany and in allied subject areas. They will be able to use the evidence based comparative studies approach to explain the evolution of organism and understand the genetic diversity and its significance.

5. The students will be able to explain various physiological and metabolicprocesses unique to plants. They would be able to elaborate on the concepts of gene, genome and the molecular processes of replication, transcription and translation.

6. They will be able to understand adaptation, development and behavior of different forms of life.The students will get an understanding of functioning of ecosystem and tracing the energy pyramids through nutrient flow.

7. Students will be able to demonstrate the experimental techniques and methods in plant sciences and have innovative research ideas. .

COURSE TEACHING-LEARNING PROCESS

The learning experiences gained for cognitive development in every student. The practical exercises help to develop an important aspect of the teaching-learning process. The important relevant teaching and learning processes involved in this course are;

1.Class lectures
2.Seminars
3. Tutorials
4. Group discussions and Workshops
5. Question framing
6. Short answer type questions
7. Long answer type questions
8. Objective type questions
9. Multiple choice questions
10. Statement, reasoning and explanation
11. Project-based learning
12. Field-based learning
13. Practical component and experiments
14. Quizzes
15. Presentations through Posters and power point
16. Internship in industry and research institutional

THEORY:

1. Lesson plan of each week will be prepared before the commencement of the session and followed during the session.
2.The theory topics are covered in lectures with the help of both conventional (chalk board and Charts) and modern (ICT) methods, including animations. .
3. Emphasis is given on interactive class room environment so as to encourage students ask questions/ doubts/ queries for clarification/explanation and discussion.
4. Students are encouraged to refer to reference books in library to inculcate reading habit for better grasp and understanding on the subject.
5. Emphasis is given to illustrations- neat, well-labelled outline and cellular diagrams/ flowcharts for improving creative skills and to substantiate the text content.
6. On completion of theory syllabus, previous years' question papers are discussed so as to apprise students about the general format of semester exam question papers.
6. Assignment (10), Test (10) and Theory Attendance (5) are components of Internal Assessment Scheme for compilation of Internal Assessment Score of each student out of 25 marks.

Practical:
1. Practical plan of each week will be prepared before the commencement of the session and followed during the session.
2. Every practical session begins with instructions, followed by students doing table work for detailed microscopic plant study.
3. Plant study is done using fixed plant materials, museum and herbarium specimens, photographs and permanent slides.

4. The students are instructed about maintaining practical records, which includes comments and diagrams.
5. Students are asked to submit practical records regularly, on a continuous basis, for checking.
6. On completion of practical syllabus, Practical Exam Guidelines are discussed to apprise students about the formant of Practical exam.
7. As part of Continuous Evaluation guidelines, total score for each student is calculated out of 25 marks, taking into consideration
8 Practical Records (10), Practical Test/ Assessment (10) and Practical Attendance (5)

Assessment Methods
A number of appropriate assessment methods of botany will be used to determine the extent to which students demonstrate desired learning outcomes. Involving students in highlighting the salient features/summary a topic through digital media such as Power Point presentationsand animations enhance their communication skill. Making drawings should be compulsory part of practical record books. A continuous assessment method throughout the programme shall inculcate regular reading habit in the students and provide continuous observation learning abilities and challenges of the students'
Following assessment methodology will be adopted:
• Oral and written examinations
• Closed-book and open-book tests,
• Problem-solving exercises,
• Practical assignments and laboratory reports,
• Observation of practical skills,
• Individual and group project reports,
• Seminar and presentations,
• Interactive sessions.
• Evaluation of answer scripts and discussion on the mistakes committed

KEYWORDS

Plant Sciences, Biology, biodiversity, biotechnology, botany, bryophytes, fungi, algae, mocrobes, bacteria, plant pathology, plant reproduction, anatomy, developmental biology, molecular biology, genetics, systematics, taxonomy, plant physiology, biostatistics, bioinformatics, ecology, biochemistry,

Contents of Courses of the Programme

Microbiology and Phycology
(BHCC1)
Core Course - (CC) Credit:6

Course Objective (2-3)

To gain knowledge of diversity, life forms, life cycles, morphology and importance of micro-organisms (Bacteria and algae).

Course Learning Outcomes

Students would have understanding of the classification, characteristic features, cell structure and growth and reproduction in viruses, bacteria, and various groups of marine and fresh water algae and their ecological and economic importance.

Unit 1

Introduction to microbial world.

Unit 2

Viruses (7 lectures): Discovery, physiochemical and biological characteristics;classification (Baltimore)General structure with special reference to viroids and prions, General account of replication, DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV). Viral diseases

Unit 3

Bacteria (8 lectures): Discovery, general characteristics, types-archaebacteria, eubacteria, wall-less forms(mycoplasma and spheroplasts), Cell structure, nutritional types, Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction), Bacterial diseases

Unit 4

Applied Microbiology (4 lectures): Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, and as causal organisms of plant diseases. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).

Unit 5

Algae (7 lectures): General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; Methods of reproduction, classification;
Criteria, system of Fritsch, and evolutionary classification of Lee (only up to groups); significant contributions of important phycologists (F.E. Fritsch, G.M. Smith, R.N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P.Iyengar).

Unit 6

Cyanophyta (6 lectures): Ecology and occurrence, range of thallus organization, cell structure, heterocyst,reproduction.economic importance; role in biotechnology. Morphology and life-cycle of Nostoc.

Unit 7

Chlorophyta (5 lectures): General characteristics, occurrence, range of thallus organization, cell structure and reproduction.Morphology and life-cycles of *Chlamydomonas, Volvox, Oedogonium, Coleochaete*.Evolutionary significance of *Prochloron*.

Unit 8

Charophyta (2 lectures): General characteristics; occurrence, morphology, cell structure and life-cycle of *Chara*;evolutionary significance.

Unit 9

Xanthophyta (3 lectures): General characteristics; range of thallus organization;Occurrence, morphology and life-cycleof *Vaucheria*.

Unit 10

Phaeophyta (6 lectures): Characteristics, occurrence, range of thallus organization, cell structure and reproduction.Morphology and life-cycles of *Ectocarpus* and *Fucus*.

Unit 11

Rhodophyta (6 lectures): General characteristics, occurrence, range of thallus organization, cell structure and reproduction.Morphology and life-cycle of *Polysiphonia*.

Unit 12: **Applied Phycology** (4 lectures): Role of algae in the environment, agriculture, biotechnology and industry.

Practical

Microbiology

1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule.
3. Gram staining.

Phycology

4. Study of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas*, *Volvox*, *Oedogonium,Coleochaete*, *Chara*, *Vaucheria*, *Ectocarpus*, *Fucus* and *Polysiphonia*, *Procholoron* through electron micrographs, temporary preparations and permanent slides

References

1. Campbell, N.A., Reece, J.B., Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky, P.V., Jackson, R.B. (2008). *Biology*, 8th edition. San Francisco, California: Pearson Benjamin Cummings.
2. Kumar, H.D. (1999). *Introductory Phycology*, 2nd edition. New Delhi, Delhi: Affiliated East-West Press.
3. Lee, R.E. (2008). *Phycology*, 4th edition. Cambridge, Cambridge: Cambridge University Press,
4. Pelczar, M.J. (2001). *Microbiology*, 5th edition. New Delhi, Delhi: Tata McGraw-Hill Co.

Additional Resources:

1. Prescott, L.M., Harley J.P., Klein D. A. (2005). *Microbiology*, 6th edition. New Delhi, Delhi: McGraw Hill.
2. Raven, F.H., Evert, R.F., Eichhorn, S.E. (1992). *Biology of Plants*. New York, NY: W.H. Freeman and Company
3. Sahoo, D. (2000). *Farming the ocean: seaweeds cultivation and utilization*. New Delhi, Delhi: Aravali International.

Teaching Learning Process

Visual media would be used for teaching. Botany Department, University of Delhi may be entrusted with preparation of good visual aids that would help students get a feel of the subject and they find the subject interesting. College teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.

Teaching Learning Plan
Week 1: Unit 1
Week 2: Unit 2
Week 3: Unit 3
Week 4: Unit 3
Week 5: Unit3
Week 6: Unit 4
Week 7: Unit 5
Week 8: Unit 5
Week 9: Unit 6
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit 7
Week 13: Unit 8
Week 14: Unit 9
Week 15: Unit 10, Unit 11
Week 16: Unit 12

Assessment Methods

1. Making drawings form the temporary preparations as practical record books
2. Involving students in highlighting the salient features of the genera/ groups through digital media such as power point presentations and animations.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
I	Outcome: Introduction to microbial world.	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
II	General structure with special reference to viroids and prions. General account of replication, DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	General characteristics, types- archaebacteria, eubacteria, wall-less forms. (mycoplasma and	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	spheroplasts). Cell structure, nutritional types,.Reproduction-vegetative, asexual and recombination		
IV	Economic importance of bacterian and viruses	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Ecology and occurrence, range of thallus organization, cell structure, heterocyst,reproduction.economic importance; role in biotechnology. Morphology and life-cycle of Nostoc.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Morphology and life-cycles of Chlamydomonas, Volvox, Oedogonium,Coleochaete.Evolutionary significance of Prochloron.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	General characteristics; occurrence, morphology, cell structure and life-cycle of Chara;evolutionary significance.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IX	Morphology and life-cycleof Vaucheria.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
X	Morphology and life-cycles of Ectocarpus and Fucus.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
XI	Morphology and life-cycle of Polysiphonia.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
XII	Role of algae in the environment, agriculture, biotechnology and industry.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Bacteria,Viruses, Algae , Cyanobacteria, algal reproduction, viroids, bacterial reproduction

Biomolecules and Cell Biology
(BHCC2)
Core Course - (CC) Credit:6

Course Objective (2-3)

Biomolecules and Cell biology study will help the students to gain knowledge on the activities in which the giant molecules and miniscule structures that inhabit the cellular world of life are engaged. This will provide inside into the organization of cell, its features and regulation at different levels. Through the study of biomolecules (i.e protein, carbohydrate, lipid and nucleic acid) and cell organelles, they will be able to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life.

Course Learning Outcomes

This course will be able to demonstrate foundational knowledge in understanding of:

1. The relationship between the properties of macromolecules, their cellular activities and biological responses
2. Understanding of Cell metabolism, chemical composition, physiochemical and functional organization of organelle
3. Contemporary approaches in modern cell and molecular biology.

Unit 1

Biomolecules (18 lectures): Types and significance of chemical bonds; Structure and properties of water; pH and buffers. **Carbohydrates**: Nomenclature and classification; Role of monosaccharides (glucose, fructose, sugar alcohols – mannitol and sorbitol); Disaccharides (sucrose, maltose, lactose), Oligosaccharides and polysaccharides (structural-cellulose, hemicelluloses, pectin, chitin, mucilage; storage – starch, inulin). **Lipids**: Definition and major classes of storage and structural lipids. Storage lipids: Fatty acids structure and functions, Structural lipid: Phosphoglycerides; Building blocks, General structure, functions and properties. Lipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers, bilayers.
Proteins: Structure of amino acids; Peptide bonds; Levels of protein structure-primary, secondary, tertiary and quarternary; Isoelectric point; Protein denaturation and biological roles of proteins
Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleic acids

Unit 2

Bioenergenetics (4 lectures): Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as a energy currency molecule.

Unit 3

Enzymes (6 lectures): Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; mechanism of action (activation energy, lock and key hypothesis, induced - fit theroy), enzyme inhibition and factors affecting enzyme activity (in brief).

Unit 4

The cell (2 lectures): Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin ofeukaryotic cell (Endosymbiotic theory).

Unit 5

Cell wall and plasma membrane (4 lectures): Chemistry, structure and function of Plant Cell Wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.

Unit 6

Cell organelles (22 lectures): Nucleus:Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin;nucleolus.
Cytoskeleton:role and structure of microtubules, microfilaments and intermediary filament.
Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.
Endomembrane system: Endoplasmic Reticulum – Structure and function of RER and SER, protein folding, processing in ER, export of proteins and lipids; Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes

Unit 7

Cell division (4 lectures)
Eukaryotic cell cycle, mitosis and meiosis. Regulation of cell cycle

Practical

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo*/*Crinum*.
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
4. Separate chloroplast pigments by paper chromatography.
5. Demonstrate the activity of any two enzymes (Urease, Amylase, Catalase).
6. Study of cell and its organelles with the help of electron micrographs.
7. Study the phenomenon of plasmolysis and deplasmolysis.

8. Study the effect of organic solvent and temperature on membrane permeability.
9. Study different stages of mitosis.

References

1. Becker, W.M., Kleinsmith, L.J., Hardin, J., Bertoni, G. P. (2009). *The World of the Cell*, 7th edition. San Francisco, Cambridge: Pearson Benjamin Cummings Publishing.
2. Berg, J.M., Tymoczko, J.L., Stryer, L. (2011). *Biochemistry*. New York, NY: W. H. Freeman and Company.
3. Campbell, M.K. (2012). *Biochemistry*, 7th edition. Boston, Massachusetts: Cengage Learning.
4. Campbell, P.N., Smith, A.D. (2011). *Biochemistry Illustrated*, 4th edition. London, UK: Churchill Livingstone.

Additional Resources:
1. Cooper, G.M., Hausman, R.E. (2009). *The Cell: A Molecular Approach*, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA.
2. Karp, G. (2010). *Cell Biology*, 6th edition. New Jersey, U.S.A.: John Wiley & Sons.
3. Majumdar, R., Sisodia, R. (2019). *Laboratory Manual of Cell Biology, with reference to Plant Cells.* New Delhi, Delhi: Prestige Publication.
4. Nelson, D.L., Cox, M.M. (2008). *Lehninger Principles of Biochemistry*, 5th edition. New York, NY: W.H. Freeman and Company.
5. Reven, F.H., Evert, R.F., Eichhorn, S.E. (1992). *Biology of Plants.* New York, NY: W.H.Freeman and Company.
6. Tymoczko, J.L., Berg, J.M., Stryer, L. (2012). *Biochemistry: A short course*, 2nd edition. New York, NY: W.H.Freeman and Company.

Teaching Learning Process

Visual media would be helpful. Botany Department, University of Delhi may be entrusted with preparation of good visual aids that would help students get a feel of thesubject and they find the subject interesting. College teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.

Teaching Learning Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam

Week 11: Mid Semester Break
Week 12: Unit VI
Week 13: Unit VI
Week 14: Unit VI
Week 15: Unit VII,

Assessment Methods

Making drawings ma be made a compulsory part of practical record books, We may ponder overmaking students involve in highlighting the salient features of the genera/ groups through digitalmedia such as ppt and animations.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
I	Structure and functions of Carbohydrates, Lipids, Proteins and Nucleic acids	Class room lectures and Practical demonstration, experiments, slides, charts	Hands on exercises, PPT, assignments, tests
II	Redox reactions. ATP: structure, its role as a energy currency molecule	Class room lectures and Practical demonstration, experiments, slides, charts	Hands on exercises, PPT, assignments, tests
III	Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; mechanism of action	Class room lectures and Practical demonstration, experiments , slides, charts	Hands on exercises, PPT, assignments, tests
IV	Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells	Class room lectures and Practical demonstration, experiments , slides, charts	Hands on exercises, PPT, assignments, tests
V	Chemistry, structure and function of Plant Cell Wall. Overview of membrane function; fluid mosaic model; Membrane transport	Class room lectures and Practical demonstration, experiments, slides, charts	Hands on exercises, PPT, assignments, tests
VI	.**Nucleus**:Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin;nucleolus. Chloroplast, mitochondria and peroxisomes: Endoplasmic Reticulum Structural organization; Function;	Class room lectures and Practical demonstration, experiments, slides, charts	Hands on exercises, PPT, assignments, tests
VII	Eukaryotic cell cycle, mitosis and meiosis.	Class room lectures and Practical demonstration, experiments, slides, charts	Hands on exercises, PPT, assignments, tests

Keywords

Proteins, lipids, carbohydrates, nucleic acids,mes, plasma membrane, cytoskeleton, chloroplast, meiosis, mitosis, cell division

Mycology and Phytopathology
(BHCC3)
Core Course - (CC) Credit:6

Course Objective(2-3)

1. To introduce students with various fungal groups and lichens, their ecology, classification, characteristics, reproduction and economic Importance
2. To introduce students with the phytopathology, its concepts and principles\
3. To acquaint with various plant diseases, causal organisms and their control

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Course Learning Outcomes

Upon completion of this course, the students will be able to:

1. Understand the world of fungi, lichens and pathogens of plants
2. Appreciate the characteristics of the fungi and lichens
3. Understand the ecological and economic significance of lichen
4. Understand the application of mycology in various fields of economic and ecologica
5. Significance
6. Understand the economic and pathological importance of fungi, bacteria and viruses
7. Identify common plant diseases and their control measures

Unit 1

Introduction to true fungi (6 lectures)
Definition, General characteristics; Affinities with plants and animals; Thallus organization;Cell wall composition; Heterokaryosis and parasexuality; Nutrition; Classification.

Unit 2

General account of Chytridiomycetes (1 lecture)

Unit 3

Zygomycota (4 lectures)
General characteristics; Ecology; Thallus organization; Life cycle with reference to *Rhizopus*.

Unit 4

Ascomycota (10 lectures)
General characteristics; Ecology; Life cycle, life cycle and classification with reference to *Saccharomyces*, *Penicillium*, *Alternaria* and *Neurospora* and *Peziza.*

Unit 5

Basidiomycota (8 lectures)
General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), *Ustilago* (loose and covered smut, symptoms only), *Agaricus*;
Bioluminescence, Fairy Rings and Mushroom Cultivation.

Unit 6

Mixomycota (Allied Fungi) (3 lectures)
General characterises; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.

Unit 7: Oomycota (4 lectures)
General characteristic; Ecology; Life cycle and classification with reference to *Phytophthora*, *Albugo*.

Unit 8: Symbiotic associations (4 lectures)
Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Economic importance of lichens. ; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Unit 9: Applied Mycology (10 Lectures)
Role of fungi in biotechnology, Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites ; Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.

Unit 10: Phytopathology (10 lectures)
Terms and concepts; General symptoms; Geographical distribution of diseases; Host- Pathogen relationships;disease cycle and environmental relation; Methods of control of plant diseases, and role of quarantine. Bacterial diseases – Citrus canker and angular leaf spot disease of Cotton.Viral diseases – Tobacco Mosaic viruses, vein clearing.

Practical

1. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, asocarps & basidiocarps).
2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Aspergillus* and Penicillium: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
4. *Peziza*: sectioning through ascocarp.
5. *Alternaria*: Specimens/photographs and temporary mounts.
6. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
7. *Agaricus:* Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*, fairy rings and bioluminescent mushrooms to be shown.
8. Study of phaneroplasmodium from actual specimens and /or photograph. Study of *Stemonitis* sporangia.
9. Albugo: Study of symptoms of plants infected with Albugo; asexual phase study throughsection/ temporary mounts and sexual structures through permanent slides.
10. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endo mycorrhiza (Photographs)
11. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early blight of potato, Black stem rust of wheat and White rust of crucifers.

References

1. Agrios, G.N. (1997). *Plant Pathology*, 4th edition. Cambridge, U.K.: Academic Press.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). *Introductory Mycology*, 4th edition. Singapore, Singapore: John Wiley & Sons.
3. Sethi, I.K. and Walia, S.K. (2011). *Text book of Fungi and Their Allies.* Noida, U.P.: Macmillan Publishers India Ltd.
4. Reven, F.H., Evert, R. F., Eichhorn, S.E. (1992). *Biology of Plants.* New York, NY: W.H. Freeman and Company.

Additional Resources

1. Sharma, P.D. (2011). *Plant Pathology.* Meerut, U.P.: Rastogi Publication.
2. Webster, J., Weber, R. (2007). *Introduction to Fungi*, 3rd edition. Cambridge, U.K.: Cambridge University Press.

Teaching Learning Process

1. The acquired knowledge in the classroom will be integrated with practical classes to impart a sound understanding of the course
2. Field visits to enhance the understanding about the ecology of fungi and lichens
3. More emphasis on physical specimens of fungi and lichens to better comprehend the morphology and other characteristics
4. Plants materials infested with diseases will be utilized for practical classes/ field visits may be planned
5. Students will be motivated to become self-directed learners by being able to monitor and adjust their approach to learning the course.

Weekly Teaching Plan
Week 1: Unit 1
Week 2: Unit 1
Week 3: Unit 2
Week 4: Unit 3
Week 5: Unit 4
Week 6: Unit 5
Week 7: Unit 6
Week 8: Unit 6
Week 9: Unit 7
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit 8
Week 13: Unit 9
Week 14: Unit 10
Week 15: Unit 10,

Assessment Methods

1. Continuous evaluation of the progress of students
2. Field based projects/reports 3. Interactive sessions/ presentations
3. Semester end evaluation of drawings as part of practical record books. We may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I	True Fungi- General characteristics; Affinities with plants and animals; Thallus organization;Cell wall composition; Heterokaryosis and parasexuality; Nutrition;	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	Classification		
Unit II	General characteristics; Affinities with plants and animals; Thallus organization;Cell wall composition; Heterokaryosis and parasexuality; Nutrition; Classification	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III	General characteristics; Ecology; Thallus organization; Life cycle with reference to *Rhizopus*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV	General characteristics; Ecology; Life cycle, life cycle and classification with reference to *Saccharomyces*, *Penicillium*, *Alternaria* and *Neurospora* and *Peziza*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V	General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), *Ustilago* (loose and covered smut, symptoms only), *Agaricus*	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI	Status of Slime molds, Classification; Occurrence; Types of plasmodia	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII	Ecology; Life cycle and classification with reference to *Phytophthora, Albugo*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII	Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Economic importance	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X	Host- Pathogen relationships; disease cycle and environmental relation; Methods of control of plant diseases, and role of quarantine. Bacterial diseases –	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	Citrus canker and angular leaf spot disease of Cotton.Viral diseases – Tobacco Mosaic viruses		

Keywords

Fungi, Ascomycota, *Puccinia*, *Agaricus*, slime molds,symbiotic association,economic importance, Fungal disease, Bacterial disease, TMV.

Archegoniatae
(BHCC4)
Core Course - (CC) Credit:6

Course Objective(2-3)

This course aims at making a familiarity with special groups of plants joined together by a common feature of *sexual reproduction involving Archegonia*.
Creating an understanding by observation and table study of representative members of phylogenetically important groups should be able to make students learn the process of evolution in a broad sense.
Study of *morphology, anatomy, reproduction and developmental changes*therein through typological study should create a knowledge base in understanding plant diversity, economic values, taxonomy of lower group of plants.

Course Learning Outcomes

The students will be made aware of the group of plants that have given rise to land habit and the flowering plants. Through field study they will be able to see these plants grow in nature and become familiar with the biodiversity. to my knowledge students should create their small digital reports where they can capture the zoomed in and zoomed out pictures as well as videos in case they are able to find some rare structure or phenomenon related to these plants.

Unit 1

The entire team feels that we need to update our concepts of the adaptations that lead to land habit. this should also include the evolution that occurred after land habit get established. There is also need to teach undergrads, APG system of classification for each of the three groups.

Unit 2

Riccia, Marchantia, Pellia, Porella, Anthoceros, Sphagnum and *Funaria* (Developmental details not to be done). Comparative and evolutionary trends in liverworts, hornworts and mosses.
Progressive sterilization of the sporophyte.
Ecological and economic importance with special reference to *Sphagnum*.besides economic importance new research in field of bryophytes could be done such as whole genome of *Marchantia polymorpha* has been sequenced to elucidate evolution.

Unit 3

Classification: Recent phylogenetic classification to be followed

Unit 4

Classification: Recent phylogenetic classification to be followed. Concept of double fertilization to be introduced taking example of *Ephedra and Gnetum gnemone. While teaching Cycas, a brief mention of Ginkgo may also be made (only similarity between Cycas and Ginkgo such as motile sperms).*Comparison of Cycadales with ferns on one hand and *Gnetum* with angiosperms should be made.

Practical

1. *Riccia* – Morphology of thallus.
2. *Marchantia*- Morphology of thallus, whole mount of rhizoids & Scales, vertical sectionof thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).
3. *Anthoceros*- Morphology of thallus, dissection of sporophyte (to show stomata, spores,pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).
4. *Pellia, Porella*- Permanent slides.
5. *Sphagnum*- Morphology of plant, whole mount of leaf (permanent slide only).
6. *Funaria*- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus,spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema.
7. *Psilotum*- Study of specimen, transverse section of synangium (permanent slide).
8. *Selaginella*- Morphology, whole mount of leaf with ligule, transverse section of stem,whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
9. *Equisetum*- Morphology, transverse section of internode, longitudinal section ofstrobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
10. *Pteris*- Morphology, transverse section of rachis, vertical section of sporophyll, wholemount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
11. *Cycas*- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll,transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide).
12. *Pinus*- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones, transverse section of Needle, transverse section of stem, longitudinal/ transverse section of male cone, whole mount of microsporophyllwhole mount of Microspores(temporary slides), longitudinal section of female cone, tangential longitudinal section & radial longitudinal sections stem (permanent slide). 13. *Gnetum*- Morphology (stem, male & female cones), transverse section of stem, verticalsection of ovule (permanent slide),
14. Botanical excursion

References

1. Kaur I.D., Uniyal P.L. (2019).*Text Book of Gymnosperms*.New Delhi, Delhi: Daya Publishing House.
2. Parihar, N.S. (1972). *An Introduction to Embryophyta. Vol. II: Pteridophyta*. Allahabad, UP: Central Book depot.
3. Parihar, N.S. (1991). *An Introduction to Embryophyta. Vol. I: Bryophyta*. Allahabad, UP: Central Book Depot.
4. Puri, P. (1985). *Bryophytes*. New Delhi, Delhi, Atma Ram and Sons.

Additional Resources

1. Bhatnagar, S.P., Moitra, A. (1996). *Gymnosperms*. New Delhi, Delhi: New Age International (P) Ltd Publishers.
2. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2008). *Biology*. San Francisco, SF: Pearson Benjamin Cummings.
3. Coulter, J.M., Chamberlain,C.J. (1910). *Morphology of Gymnosperms.* Chicago, University of Chicago Press.
4. Kaur I.D., Uniyal P.L.*Text Book of Bryophytes.* New Delhi, Delhi: Daya Publishing House (in Press).
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). *Biology*. New Delhi, Delhi:Tata McGraw Hill.
6. Singh, H. (1978). *Embryology of Gymnosperms.* Berlin, Germany. Gebruder Borntraeger.
7. Singh,V., Pandey, P.C., Jain, D.K. (2001) *A Text Book of Botany*. Meerut, UP: Rastogi and Co.
8. Vashistha, B.R., Sinha, A.K., Kumar, A. (2011).*Botany For Degree Students, Bryophyta*. New Delhi, Delhi: S Chand Publication.
9. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). *Botany For Degree Students Pteridophyta*, New Delhi, Delhi: S. Chand Publication. Delhi, India.

Teaching Learning Process

Visual media should be made available. It is suggested that Botany Department, University of Delhi may be entrusted with preparation of good visual aids that would help students get a feel of the subject and they find the subject interesting. Even the college teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.

Teaching Learnig Plan

Week 1: **Unit I** –Introduction to archegoniates, unifying features, APG system of classification
Week 2: **Unit 2**-Bryophytes- general characters, land habit and diversity
Week 3: -Classification (latest in detail of groups in syllabus), three groups in general
Week 4: -Type studies on Liverworts
Week 5: -Type studies on Mosses

Week 6: -Type study Hornworts and economic importance of bryophytes, Comparative account of liverworts, mosses and hornworts
Week 7: **Unit 3**-Pteridophytes- general characters and early land plants (*Cooksonia and Rhynia*)
Week 8: -Type studies: *Psilotum, Selaginella*, apogamy and apospory
Week 9:- Type study of *Equisetum* and *Pteris*
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12:-Heterospory and seed habit, Stellar evolution, Telome theory, Economic Importance
Week 13: **Unit 4-**Gymnosperms-general characters, concept of double fertilization
Week 14: -Life history of *Cycas* (brief mention of *Ginkgo*), *Pinus*
Week 15: -Life history of *Gnetum* and economic importance, gymnosperms vs angiosperms

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Assessment Methods

Instead of making drawings compulsory part of practical record books, we may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Assessment method

Unit No	**Coure learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
I	Introduction to archegoniates	Class room lectures and ppt	Open discussion
II	Bryophytes- general characters, land habit and diversity	Class room lectures and presentations	Group discussion
III	Classification (latest in detail of groups in syllabus), three groups in general	Class room lectures and Practical demonstration of diversity through slides and specimens	Table representation
IV	Type studies on Liverworts	Class room lectures and Practical on *Marchantia*,*Riccia*, *Pellia* and *Porella*	Sections, whole mounts, assignments, tests
V	Type studies on Mosses	Class room lectures and Practical on *Sphagnum*,*Polytrichum* and *Funaria*	Sections whole mounts, assignments, tests
VI	Type study Hornworts	Class room lectures and Practical on Anthoceros	Practical specimen studytests
VII	Pteridophytes- general characters and early land plants (*Cooksonia* and *Rhynia*)	revision	assignments, tests

VIII	Type studies: *Psilotum, Selaginella*	Class room lectures and Practical to study the vegetative and reproductive stages	assignments, tests
IX	Type study of *Equisetum* and *Pteris*	Class room lectures and Practical on *Equisetum* and *Pteris*	Hands on excercises, PPT, assignments, tests
X	EXCURSION/ EXAMS	On field study	Digital herbarium
XI	Life history of *Cycas* (brief mention of *Ginkgo*), *Pinus*	Class room lectures and Practical through temporary and permanent slides	Continuous evaluation, PPT, assignments, tests
XII	Life history of *Gnetum* and economic importance, gymnosperms vs angiosperms	Class room lectures and Practical - study of fixed material	Continuous evaluation

Keywords
Phylogenetic system of classification, Comparison of varous groups, Evolutionary trends

Anatomy of Angiosperms
(BHCC5)
Core Course - (CC) Credit:6

Course Objective (2-3)

1. To acquaint the students with internal basic structure and cellular composition of the plant body.
2. To correlate structure with important functions of different plant parts.
3. Study of various tissue systems and their development and functions in plants

Course Learning Outcomes

1. Knowledge of various cells and tissues, meristem, epidermal and vascular tissue system in plants.
2. Various aspects of growth, development of the tissues and differentiation of various plant organs.Knowledge of basic structure and organization of plant parts in angiosperms.
3. Correlation of structure with morphology and functions.

Unit 1

Tissues (12Lectures): Classification of tissues; Simple and complex tissues (no phylogeny); Pits and plasmodesmata; Wall ingrowths and transfer cells; Ergastic substances.

Unit 2

Stem and leaf(12Lectures): Organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cyto-histological zonation); Types of vascular bundles; Structure of dicot and monocot stem; Shoot Chimeras; Structure of dicot and monocot leaf, Kranz anatomy; Development of Leaf.

Unit 3

Root (6Lectures) : Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.

Unit 4

Vascular Cambium(7 Lectures): Structure (Axially and radially oriented elements); function and seasonal activity of cambium; Secondary growth in root and stem, Anomalies in secondary growth in stem: Included phloem and Phloem wedges.

Unit 5

Wood(8Lectures): Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology.

Unit 6

Periderm (3Lectures): Development and composition of periderm;rhytidome and lenticels.

Unit 7

Adaptive and Protective Systems (8Lectures): Epidermal tissue system; cuticle; epicuticular waxes;trichomes (uni-and multicellular, glandular and non-glandular, two examples of each); stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

Unit 8

Secretory System (3Lectures): Hydathodes, cavities, lithocysts and laticifers.

Unit 9: Scope of Plant Anatomy (1 Lectures)

Applications in systematics, forensics and pharmacognosy**.**

Practical

Study of anatomical details through permanent slides/temporary stain mounts/ macerations/ museum specimens with the help of suitable examples.

1. Apical meristem of root, shoot and vascular cambium.
2. Distribution and types of parenchyma, collenchyma and sclerenchyma.
3. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
4. Wood: ring porous; diffuse porous; tyloses; heartwood and sapwood.
5. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
6. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
7. Root: monocot, dicot, secondary growth.
8. Stem: monocot, dicot - primary and secondary growth; phloem wedges in *Bignonia*, included phloem in *Leptadenia*/*Salvadora*; periderm; lenticels.
9. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
10. Adaptive Anatomy: xerophytes, hydrophytes.
11. Secretory tissues: cavities, lithocysts and laticifers.

References

1. Dickison, W.C. (2000).*Integrative Plant Anatomy.* Cambridge, U.K.: Harcourt Academic Press.
2. Esau, K. (1977).*Anatomy of Seed Plants.* New Delhi, Delhi: John Wiley & Sons, Inc.
3. Evert, R.F., Eichhorn, S. E. (2006). *Esau's Plant anatomy: Mersitems, Cells, and tissues of the Plant Body: their structure, function and development.* New Jersey, U.S.: Wiley- Liss.

Additional Resources:

1. Mauseth, J.D. (1988). *Plant Anatomy*. San Francisco, California: The Benjammin Cummings Publisher.
2. Raven, F.H., Evert, R. F., Eichhorn, S.E. (1992). *Biology of Plants.* New York, NY: W.H. Freeman and Company.

Teaching Learning Process

Chalk and blackboard teaching methodology
Powerpoint presentations
Study of anatomical details through permanent slides/temporary stain mounts/ macerations/ museum specimens with the help of suitable examples

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Assessment Methods

Assignments/ Projects
Class tests, Student presentations, Continuous evaluation
Making drawings as part of practical record book. we may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.
Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Classification of tissues; Simple and complex tissues	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Organization of shoot apex (Apical cell theory, Types of vascular bundles; Structure of dicot and monocot stem, leaf, Kranz anatomy	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
Unit III:	Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	function and seasonal activity of cambium; Secondary growth in root and stem, Anomalies in secondary growth in stem	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Types of rays and axial	Class room lectures and	Hands on exercises,

	parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood	Practical demonstration, experiments	PPT, assignments, tests
Unit VI:	Development and composition of periderm;rhytidome and lenticels	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	cuticle; epicuticular waxes;trichomes (uni-and multicellular, glandular and non-glandular); stomata; Anatomical adaptations of xerophytes and hydrophytes	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Hydathodes, cavities, lithocysts and laticifers.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Applications in systematics, forensics and pharmacognosy**.**	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Tissues, Stem, Leaf, Root, Vascular cambium, Wood, Periderm, Anatomical adaptations, Secondary anomalies. Plant tissue systems, meristems, trichomes,

Economic Botany
(BHCC6)
Core Course - (CC) Credit:6

Course Objective(2-3)

To make the students familiar with economic importance of diverse plants that offer resources to human life. It emphasize the plants used as- food for man, fodder for cattle, feed for poultry, plants having medicinal value and also plant source of huge economic value etc

Course Learning Outcomes

After studying Economic Botany, students would have first hand information of plants used as food, the various kinds of nutrients available in the plants. The dietary requirements of proteins, fats, amino-acids, vitamins etc that can be met by plants. The students will learn to perform the micro-chemical tests to demonstrate various components. The students will learn about the use of fibre plants, beverages, fruits and vegetables that are integral to day to day life of plants. Students will learn to explore the regional diversity in food crops and other plants and their ethno-botanical importance as well.

Unit 1

Origin of Cultivated Plants(4 lectures): Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity (Only conventional plant breeding methods); Importance of germplasm diversity.

Unit 2

Cereals (6 lectures): Wheat and Rice (origin, evolution, morphology, post-harvest processing & uses); Green revolution; Brief account of millets and pseudocereals.

Unit 3

Unit 3: Legumes (3 lectures): General accounts (including chief pulses grown in India); Importance to man and ecosystem.

Unit 4

Fruits (3 lectures): Mango and Citrus (Origin, morphology, anatomy and uses)

Unit 5

Sugars and Starches (5 lectures): Morphology, ratooning, evolution (nobilization) and processing of sugarcane, products and by-products of sugarcane industry; Potato – morphology, tuber anatomy, propagation (conventional and TPS) and uses.

Unit 6

Spices (6 lectures): Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper

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Unit 7

Beverages (4 lectures): Tea, Coffee (morphology, processing & uses)

Unit 8

Oils and fats (8 lectures): General description, classification, extraction, their uses and health implications; groundnut, coconut, linseed, mustard (Botanical name, family & uses).

Unit 9

Essential Oils (4 lectures): General account, extraction methods, comparison with fatty oils and otheir uses.

Unit 10

Natural Rubber (3 lectures): Para-rubber: tapping, processing and uses.

Unit 11

Drug-yielding plants (5 lectures): Therapeutic and habit-forming drugs with special reference to *Cinchona*, *Digitalis*, *Papaver* and *Cannabis.*

Unit 12

Tobacco (Morphology, processing, uses and health hazards).**(3 lectures)**

Unit 13

Fibers (6 lectures): Classification based on the origin of fibers; Cotton (origin of tetraploid cotton, morphology, extraction and uses) and Jute (morphology, extraction and uses).

Practicals

1. Cereals: Wheat (habit sketch, L.S/T.S. grain, starch grains, micro-chemical tests), Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests). Millets and Pseudocereals (specimens / photographs and grains)
2. Legumes: Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. Fruits: Mango (habit sketch, L.S. fruit, micro-chemical tests in ripe fruit); Citrus (habit sketch, T.S. hesperidium, W.M. vesicle, micro-chemical tests including test for vitamin C)
4. Sugars and starches: Sugarcane (habit sketch; cane juice- micro-chemical tests); Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, W.M. starch grains, micro-chemical tests).
5. Spices: Black pepper, Fennel and Clove (habit and sections L.S./T.S.).
6. Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
7. Oils and fats: Coconut- T.S. nut, Mustard–plant specimen, seeds
8. Essential oil-yielding plants: Habit sketch of *Rosa*, *Vetiveria*, *Santalum* and *Eucalyptus* (specimens/photographs).
9. Rubber: specimen, photograph/model of tapping, samples of rubber products.
10. Drug-yielding plants: Specimens of *Cinchona*, *Digitalis*, *Papaver* and *Cannabis* (male & female plant).
11. Tobacco: specimen and products of Tobacco.
12. Fiber-yielding plants: Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for cellulose and lignin on transverse section of stem and fiber).

References

1. Kochhar, S.L. (2012). *Economic Botany in Tropics*. New Delhi, India: MacMillan & Co.
2. Wickens, G.E. (2001). *Economic Botany: Principles & Practices*.The Netherlands: Kluwer Academic Publishers.
3. Chrispeels, M.J. and Sadava, D.E. (1994) *Plants*, *Genes and Agriculture*.Jones & Bartlett - Publishers.

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of blackboard teaching and PowerPoint presentations. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers.
Practicals: Specimens along with their products are to be maintained in the museum, and explain to the students. Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have cut the section/perform micro-chemical tests of the material, the observations (temporary preparation/micro-chemical tests) has to be recorded and discussed. Any deviation from the expected trend in results is explained. Making drawings from specimens/temporary preparations in practical record books. The students

are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
College teachers can also form a group and prepare e-contents for theory as well as for practicals.

Teaching Learning Plan:

Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit IV
Week 5: Unit V
Week 6: Unit VI
Week 7: Unit VII
Week 8: Unit VIII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IX
Week 13: Unit X
Week 14: Unit XI
Week 15: Unit XII, Unit XIII

Assessment Methods

Theory: The students are continuously evaluated based on a assignments/presentation and class test. After marking, the answer scripts of the test are returned to the students.
In fact, presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation, 10 marks are alloted for test, 10 marks for record, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment Methods:

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
I	Origin of Cultivated Plants	Class room lectures and Practical	Hands on exercises, PPT, assignments, tests
II	Cereals Wheat and Rice	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Legumes	Class room lectures and Practical	Hands on exercises, PPT,

		demonstration, experiments	assignments, tests
IV	Fruits Mango and Citrus	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Sugars and Starches Sugarcane, Potato	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Spices Fennel, saffron, clove and black pepper	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Beverages Tea and Coffee	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Oils and Fats Groundnut, coconut, linseed, mustard	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IX	Essential oils	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
X	Rubber	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
XI	Drug Yielding Plants *Cinchona*, *Digitalis*, *Papaver* and *Cannabis*	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
XII	Tobacco	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
XIII	Fibers Jute and Cotton	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Cultivated plants, Green revolution, Cereals, Legumes, Starches & Sugars, Spices, Oils & Fats, Drug yielding plants, Natural rubber, Fibres

Genetics
(BHCC7)
Core Course - (CC) Credit:6

Course Objective(2-3)

To have knowledge of Mendelian and non-Mendelian inheritance, Chromosome biology and structure and function of genes.

Course Learning Outcomes

To generate interest among the students in Genetics and make them aware about the importance and opportunities in higher education and research, the first unit should be Introductory dealing with how this area has revolutionized all aspects of our life from its growth from Mendel to Genetic Engineering. Modes of inheritance of traits/ phenotypes and Phenotype-genotype corelation are the basic learning.

Unit 1

Mendelian genetics and its extension (16 L): Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; sex determination (briefly with reference to Humans and Drosophilla); Probability and Pedigree analysis; Incomplete dominance and co- dominance; Multiple allelism; lethal alleles; Epistasis; Pleiotropy; Penetrance and expressivity; Polygenic inheritance; numericals.Basics of epigenetics, DNA Methylation and epigenetic code.

Unit 2

Extra-chromosomal Inheritance (6L): Chloroplast Inheritance: Variegationin Four O` clock plant; Mitochondrial inheritance in yeast; Maternal effect- shell coiling in snails; Infective heredity- Kappa particles in Paramecium.

Unit 3

Linkage, crossing over and chromosome mapping (12L): Linkage and crossing over-Cytological basis of crossing over (eg. Maize); Recombination frequency: two factor and three factor crosses; interference and coincidence; Numericals based on gene mapping; Sex linkage (Drosophilla). QTL mapping and its significance

Unit 4

Variation in Chromosome number and structure (8L): Deletion; Duplication; Inversion; Translocation; Position effect; Euploidy and aneuploidy.

Unit 5

Gene mutations (7L): Mutation types; Molecular basis of mutation; Mutagens- Physical and chemical mutagens (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutation (CLB method); role of Transposon in mutation; DNA repair mechanisms (light dependent repair, excision repair, mismatch repair and SOS repair), Transposable genetic elements and its significance; Bacteria-IS elements, The Tn3 family Eukaryotes L Yeast TY elements, Maize transposones, Drosophila transposones; transposones in human genome; *Alu*, Retro-transposones (LINEs and SINEs)

Unit 6

Fine structure of gene (5L): Classical vs molecular concepts of gene; Cis – Trans complementation test for functional allelism; Structure of phage T4, rII locus.

Unit 7

Population and evolutionary genetics (6L): Allele frequencies, genotype frequencies, Hardy-Weinberg law, role of natural selection, mutation,genetic drift, genetic variation and speciation(modes of speciation and genetics of speciation)

Practical

1. To study male meiosis in *Allium cepa* (two stages to be shown)
2. To understand the genetic interaction involved using the seed mixture given. Genetic ratio to be calculated using Chi square analysis.
3. To do problems based on Hardy-Weinberg`s law.
4. Pedigree analysis
5. To study/list human dominant and recessive traits and to observe the listed physical traits among the students present in the class. Data thus generated may be used for calculating allelic and genotypic frequencies using Hardy- Weinberg's principle.
6. To study the syndromes (Downs, Klinefelter/Turner/Patau/Edwards)
7. To study colour blindness/ hemophilia (Ishihara cards may be used to study colour blindness)
8. Chromosomal aberrations : Complex translocation ring, quadrivalents, lagging chromosomes, diccentric/inversion bridge
9. Xeroderma / Pigmentosum/ Sickle cell anemia

References

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). *Principles of Genetics*, 8th edition. New Delhi, Delhi: John Wiley & sons.
2. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). *Introduction to Genetic Analysis*, 10th edition. New York, NY: W.H. Freeman and Co.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts of Genetics*, 10th edition. San Francisco, California: Benjamin Cummings.
4. Raven, F.H., Evert, R. F., Eichhorn, S.E. (1992).*Biology of Plants*. New York, NY: W.H. Freeman and Co.

Additional Resources

1. Hartl, D.L., Ruvolo, M. (2012). *Genetics: Analysis of Genes and Genomes*, 8th edition. New Delhi, Delhi: Jones and Bartlett Learning.
2. Snustad, D.P., Simmons, M.J. (2010). *Principles of Genetics*, 5th edition. New Delhi, Delhi: John Wiley & sons.

Teaching Learning Process

Visual media should be made available. It is suggested that Department of Genetics, University of Delhi may be entrusted with preparation of good visual aids that would help students get a feel of the subject and they find the subject interesting. Even the college teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.
Week 1: Unit 1
Week 2: Unit 1
Week 3: Unit 2
Week 4: Unit 2
Week 5: Unit 3
Week 6: Unit 3
Week 7: Unit 4
Week 8: Unit 5
Week 9: Unit 5
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit 5
Week 13: Unit 6I
Week 14: Unit 7
Week 15: Unit 7

Assessment Methods

Making drawings as part of practical record books, we may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit 1:	Mendelism Principles of inheritance; Chromosome theory of inheritance; sex determination; Probability and Pedigree analysis; Incomplete dominance and co-dominance; lethal alleles; Epistasis; Pleiotropy; Polygenic inheritance; numericals. epigenetics, DNA Methylation and	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit 2:	Chloroplast Inheritance: Variegationin Four O` clock plant; Mitochondrial inheritance in yeast; Maternal effect- shell coiling in snails; Infective heredity- Kappa particles in Paramecium	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 3:	Linkage and crossing over-Cytological basis of crossing over (eg. Maize); Recombination frequency: two factor and three factor crosses; interference and coincidence; Numericals based on gene mapping; Sex linkage (Drosophilla). QTL mapping and its significance	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 4:	Variation in Chromosome number and structure	Class room lectures and Practical demonstration, experiments	Hands on excrcises, PPT, assignments, tests
Unit 5:	Mutation types; Molecular basis of mutation; Mutagens- Physical and chemical mutagens (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutation (CLB method); role of Transposon in mutation; DNA repair mechanisms	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 6:	Classical vs molecular concepts of gene; Cis – Trans complementation test for functional allelism;	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments, tests

	Structure of phage T4, rII locus.	experiments	
Unit 7:	Allele frequencies, genotype frequencies, Hardy-Weinberg law, role of natural selection, mutation,genetic drift, genetic variation and speciation(modes of speciation and genetics of speciation)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Inheritance theory, linkage, crossing over, chromosome mapping, cytology, Gene, Gene mutation, Population genetics

Molecular Biology
(BHCC8)
Core Course - (CC) Credit:6

Course Objective(2-3)

To gain the knowledge of structure and functions of DNA and RNA

Course Learning Outcomes

1. Understanding of nucleic acid, organization of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.
2. Processing and modification of RNA and translation process, function and regulation of expression.
3. Application in biotechnology

Unit 1. Nucleic acids as carriers of genetic information 3 lectures

Historical perspective; Experiments that established nucleic acids (DNA & RNA) as the carrier of genetic information: Griffith's,Hershey & Chase, Avery, McLeod & McCarty and Fraenkel-Conrat 's experiment .

Unit 2. The Structureand organisation of the genetic material 9 lectures

DNA Structure: Miescher to Watson and Crick- a historic perspective.DNA structure , salient features of double helix ; Types of DNA: A,B & Z conformations . Genome complexity: Concept of C-value paradox, denaturation and renaturation, C_ot curves; Organization of DNA- in Prokaryotes, Viruses & Eukaryotes. Organelle DNA -- mitochondria and chloroplast DNA; Chromatin structure- Nucleosome, Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin . RNA : types of RNA molecules , structure and function of mRNA, tRNA and rRNA

Unit 3. Central Dogma and Genetic Code 3 lectures

Key experiments establishing-The Central Dogma,Genetic code (salient features & experiments that deciphered the correlation between mRNA codon and amino acid).

Unit 4. The Replication of DNA 9 lectures

Mechanism - initiation, elongation and termination, Kornberg's discovery; Enzymes and other proteins involved in DNA replication; General principles – bidirectional, semiconservative and semi discontinuous replication (Replisome), RNA priming (primase & Primosome); Various modes of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA. Replication of the 5'end of linear chromosome (end replication problem & Telomerase).

Unit 5. Mechanism of Transcription 9 lectures

Transcription in prokaryotes and eukaryotes ; Understanding the steps in process of transcription: Initiation, Elongation and Termination. Enzymes and factors involved in transcription.

Unit 6. Processing and modification of RNA 7 lectures

Split genes-concept of introns and exons, Splicing pathways, group I & group II intron splicing, Spliceosome and assembly of the spliceosome machinery , Alternative splicing, Eukaryotic mRNAprocessing (5' cap, 3' poly A tail) ; Ribozymes, RNA Editing

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Unit 7. Mechanism of Translation 10 lectures

Translationin prokaryotes and eukaryotes ; Understand the steps in process of translation - Initiation, Elongation and Termination. Enzymes and factors involved in translation. Ribosome structure and assembly (in prokaryotes and eukaryotes);charging of tRNA, aminoacyl tRNA synthetases; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

Unit 8. Gene Regulation in prokaryotes and eukaryotes 10 lectures

Basic principles of transcriptional regulation: Positive & negative; Inducible & Repressible; Activators and Repressors ; Prokaryotes: Operon concept & regulation of lactose metabolism (positive and Negative) and tryptophan synthesis (Repression-Derepression and Attenuation) in *E.coli;* Eukaryotes: Gene silencing: Methylation, RNAi, Imprinting.

Practicals

1. Preparation of LB medium and raising *E. coli*

2. DNA isolation from cauliflower heads
3. Quantification of unknown DNA by diphenylamine reagent.
4. Study of experiments establishing nucleic acid as genetic material (Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)through photographs
5. Numericals based on DNA re-association kinetics (melting profiles and $C_o t$ curves)
6. Study of DNA replication through photographs: Modes of replication - Rolling circle, Theta and semi-discontinuous ; Semiconservative model of replication (Messelson and Stahl's experiment); Telomerase assisted end-replication of linear DNA
7. Study of structures of : tRNA (2D and 3D); prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs
8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozymes and Alternative splicing
9. Understanding the regulation of lactose (*lac*) operon (positive & negative regulation) and tryptophan (*trp*) operon (Repression and De-repression & Attenuation) through photographs.
10. Understanding the mechanism of RNAi by photographs.

Suggested Readings

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc.,U.S.A. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). iGenetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.

Additional Resources

1. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.
2. Micklos D A., Freyer G.A. (2003) DNA Science: A First Course (2nd Edition), Cold Spring Harbor Laboratory; Greg A.,CSHL Press, USA

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.

When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are

discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
The students are asked to submit their record notebooks to the teacher/s **for checking.**

Weekly teaching Plan
Week 1: Unit 1
Week 2: Unit 2
Week 3: Unit 2
Week 4: Unit 3
Week 5: Unit 3
Week 6: Unit 4
Week 7: Unit 5
Week 8: Unit 6
Week 9: Unit 6
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit 7
Week 13: Unit 7
Week 14: Unit 8
Week 15: Unit 8

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.
Assessment Task

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit 1:	DNA as the carrier of genetic	Class room lectures	Hands on exercises,

	information (Griffith's, Hershey & Chase,Avery, McLeod & McCarty, Fraenkel-Conrat's experiment	and Practical demonstration, experiments	PPT, assignments, tests
Unit2:	DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, *Cot* curves; Organization of DNA- Prokaryotes, Viruses, Eukaryotes.RNA Structure_Organelle DNA -- mitochondria and chloroplast DNA.The Nucleosome_Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 3:	Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semiconservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, (theta) mode of replication, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 4:	Central dogma and genetic code (2 lectures) Key experiments establishing-The Central Dogma (), Genetic code (deciphering & salient features)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 5:	Transcription in prokaryotes; Transcription in eukaryotes	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 6:	Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I & group II intron splicing, alternative splicing eukaryotic mRNA processing(5' cap, 3' polyA tail); Ribozymes,; RNA editing.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit 7:	Mechanism of translation; Ribosome	Class room lectures	Hands on exercises,

	structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.	and Practical demonstration, experiments	PPT, assignments, tests
Unit 8:	Transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli*. Eukaryotes: transcription factors; Gene silencing: Methylation, RNAi, Imprinting.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Nucleic acids, DNA, RNA, Genetic material, Nucleosome, , DNA replication, Central dogma, genetic code,, transcription, Splicing pathways, RNA editing,, Ribosome, polypeptides

Ecology
(BHCC9)
Core Course - (CC) Credit:6

Course Objective(2-3)

To introduce the students with environmental factors affecting the plants, the basic principles of ecology and phytogeography. To make them understand complex community patterns and processes, and ecosystem functioning.

Course Learning Outcomes

It acquaint the students with complex interrelationship between organisms and environment; make them understand methods to studying vegetation, community patterns and processes, ecosystem functions, and principles of phytogeography. This knowledge is critical in evolving strategies for sustainable natural resource management and biodiversity conservation.

Unit 1

Introduction (4 lectures): Brief History, Basic concepts, Levels of organization, Inter-relationships between the living world and the environment, the components and dynamism, homeostasis (with reference to Ecosystem).

Unit 2

Soil (8 lectures): Importance; Origin; Formation; Composition: Physical, Chemical and Biological components; Soil profile; Role of climate in soil development.

Unit 3

Water (3 lectures): Importance; States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table.

Unit 4

Light, Temperature, Wind andFire (6 lectures): Variations; adaptations of plants to their variation.

Unit 5

Bioticinteractions (2 lectures): Definition; types of biotic interactions

Unit 6

Population ecology (4 lectures): Distribution and characteristics of populations; population growth; population dynamics; Ecological Speciation (Ecads, ecotypes, ecospecies, etc)

Unit 7

Plantcommunities(9 lectures): Concept of ecological amplitude; Habitat (types) and Ecological niche (types); Community characters (analytical and synthetic); Ecotone and edge effect; Methods to studying vegetation; Dynamics of communities; Succession: processes, types (Lithosere, Hydrosere); climax concepts.

Unit 8

Ecosystems (5 lectures): Structure; Types; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids.

Unit 9

Functional aspects ofecosystem **(9 lectures):** Principles and models of energy flow; Production and productivity; Measurement of productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.

Unit 10

Phytogeography (10 lectures): Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India; Vegetation of Delhi.

Practical

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovi bond comparator and pH paper)
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
4. Determination of organic matter of different soil samples by Walkley & Black rapid titration method.
5. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
6. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
7. (a). Study of morphological adaptations of hydrophytes and xerophytes (four each).
   (b). Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Rootparasite (Orobanche), Epiphytes, Predation (Insectivorous plants).

8. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
11. Field visit to familiarize students with ecology of different sites.

References

1. Odum, E.P. (2005). *Fundamentals of Ecology*. New Delhi, India: Cengage Learning India Pvt. Ltd., 5th edition.
2. Kormondy, E.J. (1996). *Concepts of Ecology*. New Delhi, India:PHI Learning Pvt. Ltd. 4th edition.
3. Sharma, P.D. (2010). *Ecology and Environment*. Meerut, India: Rastogi Publications. 8th edition
4. Singh, J.S., Singh, S.P., Gupta, S.R. (2014). *Ecology, Environmental Science and Conservation.* New Delhi, India: S. Chand.

Additional Resources:

1. Ambasht, R.S. and Ambasht, N.K. (2008). *A text book of Plant Ecology*, CBS Publishers & Distributors PVT. LTD.
2. Majumdar, R and Kashyap, R (2019). *Practical Manual of Ecology and Environmental Science*, New Delhi, India: Prestige Publishers
3. Singh, J.S., Singh, S.P., Gupta, S. (2006). *Ecology, Environment and Resource Conservation.* New Delhi, India: Anamaya Publications.
4. Wilkinson, D.M. (2007). *Fundamental Processes in Ecology*. USA: An Earth Systems Approach.Oxford University Press.

Teaching Learning Process

The Class room teaching is integrated with practical classes, and field visit to impart a sound understanding of the course. The theory topics are covered in lectures with the help of blackboard teaching and PowerPoint presentations. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers.
Every practical session begins with detailed instructions, followed by students conducting the experiment/s in the laboratory/college campus. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
College teachers can also form a group andprepare e-contents for theory as well as for practicals.

Field visit is also be organised to familarise the students with local plant species, and to understand community pattern and processes.

Teaching Learning Plan:
Week 1: Unit I
Week 2: Unit II
Week 3: Unit II
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit V
Week 7: Unit VI
Week 8: Unit VII
Week 9: Unit VII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit IX
Week 14: Unit IX, Unit X
Week 15: Unit X

Assessment Methods

Theory: The students are continuously evaluated based on a assignments/presentation and class test. After marking, the answer scripts of the test are returned to the students.
In fact, presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks. **Practicals:** For continuous evaluation, 10 marks are alloted for test, 10 marks for record /field report, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Introduction	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Soil	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments,

		experiments	tests
III	Water	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Light, Temperature, Wind and Fire	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Biotic Interactions	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Population Ecology Distribution and characteristics of populations; population growth; population dynamics; Ecological Speciation	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Plant Communities Concept of ecological amplitude; Habitat and Ecological niche; Community characters (analytical and synthetic); Ecotone and edge effect; Methods to studying vegetation; Dynamics of communities; Succession	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Ecosystems Structure; Types; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IX	Functional aspects of ecosystems Principles and models of energy flow; Production and productivity; Measurement of productivity; Ecological efficiencies; Biogeochemical cycles	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
X	Phytogeography Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes; Phytogeographical division of India; Vegetation of Delhi	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Environmental factors, Soil profile, Biotic interactions, Ecological niche, Succession, Ecosystem functions, Homeostasis, Endemism, Phytogeography

Plant Systematics
(BHCC10)
Core Course - (CC) Credit:6

Course Objective (2-3)

To gain the knowledge on the taxonomy, phylogeny of plants

Course Learning Outcomes

Understanding of systematics its importance in bioresource utilization and biodiversity management.Nomenclature pattern, Phylogeny, Classification systems of the plants.

Unit 1

Plant identification, Classification, Nomenclature, Biosystematics (2 lectures)

Unit 2

Identification (6 lectures)
Field inventory; Herbarium Techniques; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual Herbarium; E-flora: Flora, Monographs, Journals; Keys: Single Access and Multi-access.

Unit 3

Systematics-an interdisciplinary science (6 lectures)
Evidence from palynology, cytology, phytochemistry [Alkaloids, Phenolics, Glucosides, terpenes and Semantides (in brief)] and molecular data (cp.DNA, mt-DNA, nuclear DNA, PCR amplification, sequence data analysis)

Unit 4

Taxonomic hierarchy (6 lectures)
Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary)

Unit 5

Botanical nomenclature (10 lectures)
Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids and cultivated plants.

Unit 6

Systems of classification (10 lectures)
Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Benthan and Hooker (up to series) and Engler and Prantl (up to series); Brief references of Angiosperm Phylogeny Group (APG IV) classification.

Unit 7

Biometrics and numerical taxonomy (8 lectures)
Characters; Variations; OTUs, character weighing and coding; cluster analysis; Phenograms

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Unit 8

Phylogeny of Angiosperms (12 lectures)
Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Cladistics; methods of illustraring evolutionary relationships (phylogenetic tree, cladogram)

Practical

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formul/e and systematic position according to Bentham and Hooker's system of classification)
Ranunculaceae- *Ranunculus*, *Delphinium*
Brassicaceae- *Brassica*, *Alyssum/ Iberis*
Myrtaceae- *Eucalyptus*, *Callistemon*
Umbelliferae-*Coriandrum/ Anethum/ Foeniculum*
Asteraceae- *Sonchus/ Launaea*, *Veronia/ Ageratum*, *Elipta/ Tridax*
Solanaceae- *Solanum nigrum/ Withania*
Lamiaceae- *Salvia/Ocimum*
Euphorbiaceae-*Euphorbia hirta/ E.milli*, *Jatropha*
Liliaceae- *Asphodelus/ Lilium/ Allium*
Poaceae- *Triticum/ Hordeum/ Avena*
Malvaceae-*Abutilon/ Hibiscus/ sida*
Caryophyllaceae-*Stellaria/ Dianthus*

Apocyanaceae- *Vinca rosea*
Asclepediaceae- *Calotropis procera*
Moraceae- *Morus alba*
Chenopodiaceae- Chenopodium alba
Cannaceae- *Canna indica*
Ten familes should be selected out of the given list of seveteen families representing the following
Class/ Subclass as mentioned below:
Polypetalae- Any 3 families
Gamopetalae- Any 3 families
Monochlamydeae- Any 2 families
Monocotyledons- Any 2 families
2. Field visit (local)- Subject to grant funds from the University
3. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

References

1. Reven, F.H., Evert, R. F., Eichhorn, S.E. (1992). *Biology of Plants.* New York, NY: W.H. Freeman and Company.
2. Singh, G. (2012). *Plant Systematics: Theory and Practice*, 3rd edition. New Delhi, Delhi: Oxform and IBH Pvt. Ltd.

Teaching Learning Process

Field visits to the forested areas and on the spot Plant identification feature would be very helpful. Visual media should be made available. It is suggested that Botany Department, University of Delhi may be entrusted with preparation of good visual aids that would help students get a feel of the subject and they find the subject interesting. Even the college teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.
Week 1: Unit I
Week 2: Unit II
Week 3: Unit II
Week 4: Unit Local Field visit
Week 5: Unit III
Week 6: Unit III
Week 7: Unit IV
Week 8: Unit V
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break

Week 12: Unit VI
Week 13: Unit VII
Week 14: Unit VIII
Week 15: Unit VIII

Assessment Methods

Making drawings from the live specimens should compulsory part of practical record books. We may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Plant identification, Classification, Nomenclature, Biosystematics	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Herbarium Techniques; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; E-flora: Flora, Monographs	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	palynology, cytology, phytochemistry [Alkaloids, Phenolics, Glucosides, terpenes and Semantides and molecular data	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary)	Class room lectures and Practical demonstration, experiments	Hands on excrcises, PPT, assignments, tests
Unit V:	Botanical nomenclature-Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids and cultivated plants	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	Cronquist; Classification systems of Benthan and Hooker (up to series) and Engler and Prantl (up to series); Angiosperm Phylogeny Group (APG IV)		
Unit VII:	Biometrics and numerical taxonomy	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Cladistics; methods of illustraring evolutionary relationship	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Plant Taxonomy, plant classification, Flora, plant nomenclature, phylogeny, cladogram

Reproductive Biology of Angiosperms
(BHCC11)
Core Course - (CC) Credit:6

Course Objective(2-3)

To have knowledge of the flowering and fruiting, reproduction process, role of pollinators, ovule and seed development.

Course Learning Outcomes

Student would have an understanding of

1. Induction of flowering and molecular and genetic aspects of flower development.
2. Pollen development, dispersal and pollination
3. Ovule development and fertilization,
4. Endosperm development and its importance
5. alternation pathways of reproduction
6. Student would be able to apply this knowledge for conservation of pollinators and fruit development

Unit 1

Introduction (2 lectures)
History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope of Reproductive Biology.

Unit 2

Anther (4 lectures)
Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance.

Unit 3

Pollen biology (8 lectures)
Micro-gametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system (no details but table to be included); Palynology and scope (a brief account); Pollen wall proteins;

Pollen viability, storage and germination; Unique features: Pseudomonads, polyads, massulae, pollinia.

Unit 4

Ovule (8 lectures)
Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac; Female germ Unit

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Unit 5

Pollination and fertilization (6 lectures)
Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; structure of pollen tube; double fertilization.

Unit 6

Self incompatibility (8 lectures)
Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intraovarian and in vitro pollination; Modification of stigma surface, parasexual hybridization; Cybrids(in brief with examples) , in vitro fertilization.

Unit 7

Endosperm (4 lectures)
Types (2 examples each), development, structure and functions.

Unit 8

Embryo (6 lectures)
Six types of Embryogeny (no details) ; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia***.**

Unit 9

Seed (4 lectures)
Structure, importance and dispersal mechanisms(Adaptations – Autochory, Anemochory, Hydrochory, Zoochory with 2 examples each).

Units 10

Polyembryony and apomixes (6 lectures)
Introduction; Classification (given by Bhojwani and Bhatnagar); Causes and applications.

Unit 11

Germline transformation (4 lectures)
Pollen grain and ovules through pollen tube pathway method

Practical

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
2. Pollen grains: Fresh pollen showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs,fresh material), ultrastructure of pollen wall(micrograph); Pollen viability: Tetrazolium test.germination: Calculation of percentage germination in different media using hanging drop method.
3. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).
4. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
5. Intra-ovarian pollination; Test tube pollination through photographs.
6. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
7. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.
8.Seed dispersal mechanisms (adaptations through photographs / specimens)
9.Flourescent Microscopes can be purchased for the colleges.
(a) Study of pollen cytology to see 2-celled and 3-celled pollen grains.
(b) To perform pollen culture.
(c) To isolate protoplast from pollen grains.
(d) To study pollen-pistil interactions (fluorescent microscopes).

References

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). *The Embryology of Angiosperms*, 5th edition. New Delhi, Delhi: Vikas Publishing House.
2. Johri, B.M. (1984). *Embryology of Angiosperms.* Netherlands: Springer-Verlag.
3. Raghavan, V. (2000). *Developmental Biology of Flowering plants.* Netherlands: Springer

4. Shivanna, K.R. (2003). *Pollen Biology and Biotechnology*. New Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
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Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit III
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Week 6: Unit V
Week 7: Unit VI
Week 8: Unit VII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit IX
Week 14: Unit X
Week 15: Unit XI

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the

content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.

An assignment can be given in place of the presentation.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Scope of Reproductive Biology contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison)	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Micro-gametogenesis; Pollen wall structure, NPC system; Palynology and scope; Pollen wall proteins; Pollen viability, storage and germination	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Ovule Structure; Types; endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (*Polygonum* type); Organization and ultrastructure of mature embryo sac	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; structure of pollen tube; double fertilization.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Methods to overcome self-incompatibility: mixed pollination, bud pollination, stub	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments, tests

	pollination; Intraovarian and in vitro pollination; Modification of stigma surface, parasexual hybridization; Cybrids	experiments	
Unit VII:	Endosperm types, development, structure and functions	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo;	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Seed structure, importance and dispersal mechanisms(Adaptations – Autochory, Anemochory, Hydrochory, Zoochory	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X:	Polyembryony and apomixes	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit XI:	Pollen grain and ovules through pollen tube pathway method	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Development, flowering, anther, pollen biology, ovule, gametogenesis, Pollination, fertilization, self -incompatibility, endosperm, seed, apomixis, polyembryony

Plant Physiology
(BHCC12)
Core Course - (CC) Credit:6

Course Objective(2-3)

The course aims at making students realize how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology.

Course Learning Outcomes

The students are able to correlate morphology, anatomy, cell structure and biochemistry with plant functioning. The link between theory and practical syllabus is established, and the employability of youth would be enhanced. The youth can also begin small-scale enterprises.

Unit 1

Plant water relationship (10 lectures)
Water potential and its components, water absorption by roots, aquaporins, pathway of water movement--symplast, apoplast, transmembrane pathways, root pressure, guttation, ascent of sap--cohesion-tension theory, transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement--starch-sugar hypothesis, proton transport theory, blue light stimulated response.

Unit 2

Mineral nutrition (8 lectures)
Essential and beneficial elements, macro- and micronutrients, methods of study and use of nutrient solutions (ash analysis, hydroponics, aeroponics), criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents (including phytosiderophores).

Unit 3

Nutrient uptake (8 lectures)
Soil as a nutrient reservoir, transport of ions across cell membrane--passive absorption: simple (Fick’s law) and facilitated diffusion (carrier and channel proteins), active absorption, proton ATPase pump, electrochemical gradient, ion flux, uniport, co-transport (symport, antiport), role of mycorrhizae (in brief).

Unit 4

Translocation in the phloem (6 lectures)
Experimental evidence in support of phloem as the site of sugar translocation, composition of phloem sap, aphid stylet technique, Pressure-Flow Model, phloem loading and unloading, source-sink relationship.

Unit 5

Plant growth regulators (16 lectures)
Discovery, chemical nature (basic structure, precursor), bioassay, physiological roles and commercial applications of Auxins, Gibberellins, Cytokinins, Abscisic Acid, Ethylene; brief introduction: mechanism of action of auxins; Brassinosteroids and Jasmonic acid (brief introduction).

Unit 6

Physiology of flowering (6 lectures)
Photoperiodism, concept of florigen, CO-FT Model for long-distance transport of flowering stimulus, ABC model of flowering (in brief), vernalization, seed dormancy (causes and methods to overcome dormancy).

Unit 7

Phytochrome (6 lectures)
Discovery, chemical nature, role of phytochrome in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

Practical

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Determination of water potential of given tissue (potato tuber) by falling drop method.
4. Study of the effect of light on the rate of transpiration in excised twig/ leaf.
5. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and a xerophyte.
6. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and a xerophyte (any one surface).
7. To study the phenomenon of seed germination (effect of light and darkness).
8. To study the induction of amylase activity in germinating barley grains.

Demonstration experiments

1. To demonstrate suction due to transpiration.
2. Fruit ripening.
3. Rooting from cuttings.
4. Bolting experiment.
5. To demonstrate the delay of senescence by cytokinins

References

1. Bajracharya, D. (1999). *Experiments in Plant Physiology: A Laboratory Manual*. New Delhi, Delhi: Narosa Publishing House.
2. Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism*. Singapore: Springer Nature, Singapore Pvt. Ltd.
3. Hopkins, W. G., Huner, N. P. A. (2009). *Introduction to Plant Physiology*, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd.
4. Kochhar, S.L., Gujral, S.K. (2017). *Plant Physiology: Theory and Applications*. New Delhi, Delhi: Foundation Books, Cambridge University Press India Pvt, Ltd.

Additional Resources:
6. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). *Plant Physiology and Development*, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.

Weekly Teaching Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
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Week 5: Unit III
Week 6: Unit III
Week 7: Unit VI
Week 8: Unit IV
Week 9: Unit V

Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit VI
Week 14: Unit VII
Week 15: Unit VII
The students are asked to submit their record notebooks to the teacher/s for checking.

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.
Assessment Task
Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Water potential and its components, water absorption by roots, aquaporins, pathway of water movement, root pressure, guttation, ascent of sap, transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement--starch-sugar hypothesis, proton transport theory, blue light stimulated response.	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Essential and beneficial elements, macro- and micronutrients, methods	Class room lectures and Practical	Hands on exercises, PPT, assignments, tests

	of study and use of nutrient solutions (ash analysis, hydroponics, aeroponics), criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents	demonstration, experiments	
Unit III:	Soil as a nutrient reservoir, transport of ions across cell membrane--passive absorption: simple (Fick's law) and facilitated diffusion (carrier and channel proteins), active absorption, proton ATPase pump, electrochemical gradient, ion flux, uniport, co-transport (symport, antiport), role of mycorrhizae	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Experimental evidence in support of phloem as the site of sugar translocation, composition of phloem sap, aphid stylet technique, Pressure-Flow Model, phloem loading and unloading, source-sink relationship	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	physiological roles and commercial applications of Auxins, Gibberellins, Cytokinins, Abscisic Acid, Ethylene; brief introduction: mechanism of action of auxins; Brassinosteroids and Jasmonic acid	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Photoperiodism, concept of florigen, CO-FT Model for long-distance transport of flowering stimulus, ABC model of flowering (in brief), vernalization, seed dormancy	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	role of phytochrome in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Movement of water, ascent of sap, transpiration, stomatal movements, mineral nutrients, active and passive transport, translocation, plant growth regulators, photoperiodism, photomorphogenesis

Plant Metabolism
(BHCC13)
Core Course - (CC) Credit:6

Course Objective(2-3)

1. A comprehensive study of different pathways including their biochemistry and to some extent the molecular details.
2. Current understanding of regulation and integration of metabolic processes in plants with reference to crop productivity.
3. Significance of metabolic pathways for metabolic engineering in producing transgenics.
4. To gain the knowledge of physiological and biochemical processes in the plant system

Course Learning Outcomes

- Concept and significance of metabolic redundancy in plants.
- Students will also be able to learn the similarity and differences in metabolic pathways in animals and plants.
- To have understanding of water and nutrient uptake and movement in plants, role of minerl elements, translocation of sugars, Role of various plant growth regulatoras, phytochrome cytochromes and phototropins, and flowering stimulus.

Unit 1

Concept in Metabolism (4lectures)
Introduction, anabolic and catabolic pathways, Principles of thermodynamics, coupled reactions

Unit 2

Enzymes (10 lectures)
Historical Background, structure, nomenclature and classification of enzymes, Mechanism of action (activation energy, lock and key, induced fit model), Michaelis Menten equation, enzyme inhibition (competitive, non-competitive and uncompetitive), factors affecting enzyme activity, role of regulatory enzymes, allosteric regulation and covalent modulation, isozymes and alloenzymes

Unit 3

Carbon assimilation (14 lectures)

Historical background, concept of light-action and absorption spectra, photosynthetic pigments, role of photosynthetic pigments (chlorophyll and accessory pigments (no structural details), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, photophosphorylation, PSI, PSII, Q cycle, CO2 reduction, photorespiration, C4 pathways, Crassulacean acid metabolism, factors affecting CO2 reduction

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Unit 4

Carbohydrate metabolism (2lectures)
Metabolite pool and exchange of metabolites, synthesis and catabolism of sucrose and starch (no structural details)

Unit 5

Carbon Oxidation (10 lectures)
Historical Background of Glycolysis and Krebs cycle, Glycolysis, fate of pyruvate- aerobic and anaerobic respiration and fermentation, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of Kerbs cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

Unit 6

ATP synthesis (4lectures)
Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyer's conformational model, Racker's experiement, Jagendorf's experiement, role of uncouplers, P/O ratio

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Unit 7

Lipid Metabolism (8 lectures)
Synthesis and breakdown of triglycerides, -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilization of lipids during seed germination, -oxidation.

Unit 8

Nitrogen Metabolism (8 lectures)
Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes), Physiology and biochemistry of nitrogen fixation, Ammonia assimilation (GS-GOGAT), reductive amination and transamination.

Practical

1.To study the activity of urease enzyme and effect of substrate concentration and temperature on enzyme activity.
2. To study the activity of catalase enzyme and effect of heavy metal and pH on enzyme activity.
3. To study the activity of peroxidase and tryosinase and effect of inhibitor (phenylthiourea of tryosinase and sodium azide of peroxidase) on any one of the enzymes.
4. Chemical separation of photosynthetic pigments.
5. Experimental demonstration of Hill's reaction.
6. To demonstrate and verify Blackman's law of limiting factors.
7. To compare the rate of respiration in different parts of a plant (at least 3 parts).
8. To study activity of Nitrate reductase in leaves of two plant sources.
9. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
10. Demonstration of fluorescence by isolated chlorophyll pigments.
11. Demonstration of absorption spectrum of photosynthetic pigments.
12. Demonstration of respiratory quotient (RQ).

References

1. Bhatla, S.C., Lal,M.A. (2018). *Plant Physiology, Development and Metabolism.* Singapore: Springer.
2. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). *Biochemistry and Molecular Biology of Plants*, 2nd edition. New Jearsey, U.S.: Wiley Blackwell.
3. Hopkins, W.G., Huner, N. (2008). *Introduction of Plant Physiology*, 4th edition. New Jearsey, U.S.: John Wiley and sons.
4. Jones, R.,Ougham, H., Thomas,H.,Waaland, S. (2013). *The molecular life of plants.* Chichester, England: Wiley-Blackwell.

Additional Resources:
5. Nelson, D.L., Cox, M.M. (2017). *Lehninger Principle of Biochemistry*, 7th edition. New York, NY: W.H. Freeman, Macmillan learning.
6. Taiz, L., Zeiger, E., MØller, I.M., Murphy, A. (2015). *Plant Physiology and Development*, 6th edition. Massachusetts: Sinauer Associates Inc.Sunderlands.

Teaching Learning Process

The experiments included in the paper are performed individually or in group and are followed by group discussions and interjections.
The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any

deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
The students are asked to submit their record notebooks to the teacher/s for checking.

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Week 15: Unit VIII

Assessment Methods

Students are continuously assessed during practical class.
Submission of class records is mandatory. This exercise develops scientific skill as well as methods of recording and presenting scientific data.
Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	anabolic and catabolic pathways, Principles of thermodynamics, coupled reactions	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Enzymes mechanism of action (activation energy, lock and key, induced fit model), Michaelis Menten equation, enzyme inhibition, factors affecting enzyme activity, role of regulatory enzymes, allosteric regulation and covalent modulation, isozymes and alloenzymes	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	photosynthetic pigments, role of photosynthetic pigments	Class room lectures and Practical	Hands on exercises, PPT, assignments, tests

	(chlorophyll and accessory pigments (no structural details), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, photophosphorylation, PSI, PSII, Q cycle, CO2 reduction, photorespiration, C4 pathways, Crassulacean acid metabolism, factors affecting CO2 reduction	demonstration, experiments	
Unit IV:	Metabolite pool and exchange of metabolites, synthesis and catabolism of sucrose and starch	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Glycolysis, fate of pyruvate-aerobic and anaerobic respiration and fermentation, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of Kerbs cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyer's conformational model, Racker's experiement, Jagendorf's experiement, role of uncouplers	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	Synthesis and breakdown of triglycerides, -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilization of lipids during seed germination, -oxidation.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes), Physiology and biochemistry of nitrogen fixation, Ammonia assimilation (GS-GOGAT), reductive amination and transamination.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Bioenergetics, Coupled reactions, allosteric regulation, photochemical reaction, Glyoxylate cycle, Electron transport chain, ATP synthase, triglycerides, nitrogenase,Anabolism, catabolism, carbon assimilation, carbon oxidation, Lipid metabolism, nitrogen metabolism, signal transduction

Plant Biotechnology
(BHCC14)
Core Course - (CC) Credit:6

Course Objective(2-3)

1. The objective of the course is to give students new knowledge and widening of the knowledge acquired in other course by handling of classical and modern plant biotechnology processes, including tissue culture for healthy plants, plants with improved characteristics.
2. This course explores the use of biotechnology to both generate genetic variation in plants and to understand how factors at the cellular level contribute to the expression of genotypes and hence to phenotypic variation.
3. Understanding of biotechnological processes such as recombinant DNA technology and its applicative value in pharmaceuticals (vaccines, antibodies, antibiotics etc.), food industry (transgenic crops with improved qualities (nutraceuticals, industrial enzymes etc.), agriculture (biotic and abiotic stress tolerant plants, disease and pest resistant plants, improved horticultural varieties etc.), ecology (plants role in bioremediation). This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture.
4. In the laboratory classes, students will perform some of the techniques currently used to generate information and detect genetic variation.

Course Learning Outcomes

The successful students will be able to:

- Learn the basic concepts, principles and processes in plant biotechnology.
- Have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.
- Use basic biotechnological techniques to explore molecular biology of plants
- Explain how biotechnology is used to for plant improvement and discuss the biosefty concern and ethical issue of that use.

Unit 1

Plant Tissue Culture (12 lectures)
Historical perspective, Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Plasticity andTotipotency; Organogenesis; Embryogenesis (somatic and zygotic);

Unit 2

Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and cybrids; Cryopreservation; Germplasm Conservation).

Unit 3

Recombinant DNA technology (32 lectures)
Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (PUC 18 and pUJC19, pBR322. Ti plasmid, BAC); Lambda phage, Ml 3 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC and briefly PAC,).

Unit 4

Gene Cloning (Recombinant DNA. Bacterial Transformation and selection of recombinant clones, PCR and RT-PCRmediated gene cloning); Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligonucleotide, heterologous, PCR; Methods of gene transfer- Agrohacterium-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment: Selection of transgenics— selectable marker and reporter genes (Luciferase, GUS, GFP).DNA fingerprinting by RAPD and RFLP;

Unit 5

Applications of Biotechnology (16 lectures)
Engineering plants to overcome abiotic (drought and salt stress) and biotic stress Pest resistant (Bt-cotton) and herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (FlavrSavr tomato. Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug)

Unit 6

Molecular farming(Plants as bioreactors)for edible vaccines, antibodies, polymers, biodegradable plastics(PHA), biomass utilization andindustrial enzymes) (- amylase, phytase, lignocelluloses degrading enzymes); Biosatety concerns.

Practical

l. (a) Preparation of Murashige & Skoog's (MS) medium.
(b) Demonstration of in vitro sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
2. Study of anther. embryo and endosperm culture, micropropagation. somatic embryogenesis & artificial seeds through photographs.
3. Isolation of protoplasts.
4. Construction of restriction map of circular and linear DNA from the data provided.
5. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
6. Study of steps of genetic engineering for production of *Bt* cotton, Golden rice, FlavrSavr tomato through photographs.
7. Isolation of plasmid DNA.
8. Restriction digestion and gel electrophoresis of plasmid DNA (demonstration/ photograph).
9. Calculate the percentage similarity between different cultivars of a species using RAPD profile. Construct a dendrogram and interpret results.

References

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). *The Embryology of Angiosperms*, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
2. Bhojwani, S.S., Razdan, M.K., (1996). *Plant Tissue Culture: Theory and Practice.* Amsterdam, Netherlands: Elsevier Science.
2. Glick, B.R., Pasternak, J..J.(2010). *Molecular Biotechnology: Principles and Applications.* Washington, U.S.: ASM Press.
4. Snustad, D.P.,Simmons, M.J. (2010). *Principles of Genetics*, 5th edition. Chichester, England: John Wiley and Sons.

Additional Resources

1. Stewart, C.N. Jr. (2008). *Plant Biotechnology and Genetics: Principles, Techniques and Applications.* New Jearsey, U.S.: John Wiley & Sons Inc.

Teaching Learning Process

1) Problem oriented learning
2) Individual seminar
3) Presentation and interpretation to other students
4) Discussion of published research articles on the selected topics
5) Practical will introduce the students to a range of tools and techniques of biotechnology
Week 1: Unit I
Week 2: Unit I
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Week 15: Unit VI

Assessment Methods

Assessment must encourage and reinforce learning.
Assessment must enable robust and fair judgments about student performance.
Assessment practices must be fair and equitable to students and give them the opportunity to demonstrate what they have learned.
Assessment must maintain academic standards.
Assessment will be by written class test, assignment, project work, viva for internal assessment and written theory and practical examination for university evaluation.

Assessment method

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Plasticity andTotipotency; Organogenesis; Embryogenesis	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and cybrids; Cryopreservation; Germplasm Conservation).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (PUC 18 and pUJC19, pBR322. Ti plasmid,	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	BAC); Lambda phage, Ml 3 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC and briefly PAC,).		
Unit IV:	Gene Cloning (Recombinant DNA. Bacterial Transformation and selection of recombinant clones, PCR and RT-PCRmediated gene cloning); Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligonucleotide, heterologous, PCR; Methods of gene transfer-Agrohacterium-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment: Selection of transgenics— selectable marker and reporter genes (Luciferase, GUS, GFP).DNA fingerprinting by RAPD and RFLP	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Engineering plants to overcome abiotic (drought and salt stress) and biotic stress Pest resistant (Bt-cotton) and herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (FlavrSavr tomato. Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Molecular farming(Plants as bioreactors)for edible vaccines, antibodies, polymers, biodegradable plastics(PHA), biomass utilization andindustrial enzymes) (- amylase, phytase, lignocelluloses degrading enzymes); Biosafety concerns	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Tissue culture, micropropagation, organogenesis, totipotency, cryopreservation, recombinant DNA technology, Gene cloning , gene transfer, , electroporation microinjection, DNA library, transgenic crops, Humulin, biosafety, edible vaccines,

Analytical Techniques in Plant Sciences
(BHDS1)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

To gain the knowledge on various techniques and instruments used for the study of plant biology

Course Learning Outcomes

Understanding of principles and use of light, confocal transmission and electron microscopy, centrifugation, spectrophotometry, chromatography, x-ray diffraction technique and chromatography techniques

Unit 1

Imaging and related techniques (15 lectures)
Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2

Cell fractionation (8 lectures)
Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, $CaCl_2$ gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3

Radioisotopes (4 lectures)
Use in biological research, auto-radiography, pulse chase experiment.

Unit 4

Spectrophotometry (4 lectures)
Principle and its application in biological research.

Unit 5

Chromatography (8 lectures)
Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6

Characterization of proteins and nucleic acids (6 lectures)
Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE

Practical

1.Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. Demonstration of ELISA.
3. To separate nitrogenous bases by paper chromatography.
4. To separate sugars by thin layer chromatography.
5. Isolation of chloroplasts by differential centrifugation.
6. To separate chloroplast pigments by column chromatography.
7. To estimate protein concentration through Lowry's methods.
8. To separate proteins using PAGE.
9. To separation DNA (marker) using AGE.
10. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
11. Preparation of permanent slides (double staining).

References

1. Plummer, D.T. (1996). *An Introduction to Practical Biochemistry*, 3rd edition. New Delhi, Delhi: Tata McGraw-Hill Publishing Co. Ltd.
2. Ruzin, S.E. (1999). *Plant Microtechnique and Microscopy*. New York, NY: Oxford University Press.

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.

When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.

The students are asked to submit their record notebooks to the teacher/s for checking.

Weekly Plan

Week 2: Unit I

Week 3: Unit I

Week 4: Unit II

Week 5: Unit II

Week 6: Unit III

Week 7: Unit III

Week 8: Unit IV

Week 9: Instrumentation lab visit

Week 10: Mid semester Exam

Week 11: Mid Semester Break

Week 12: Unit V

Week 13: Unit VI

Week 14: Unit VI

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.

Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.

An assignment can be given in place of the presentation.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CaCl2 gradient, analytical centrifugation, ultracentrifugation, marker enzymes.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Radioisotopes and their Use in biological research, auto-radiography, pulse chase experiment.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Principle and its application in biological research.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Microscopy, Flow cytometry, Chromosome banding, FISH, SCM, Centrifugation, radioisotopes, spectrophotometry, chromatography, electrophoresis, PAGE, mass spectrometry

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Bioinformatics
(BHDS4)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

A computer-based approach is now central to biological research. Bioinformatics operates at the intersection of biology and informatics and has a strong mathematical component. Training students in various aspects of Bioinformatics is the objective of this course.

Course Learning Outcomes

With a working knowledge of the practical and theoretical concepts of bioinformatics, you will be well qualified to progress onto advanced graduate study. The portfolio of skills developed on the programme is also suited to academic research or work within the bioinformatics industry as well as range of commercial settings.

Unit 1

Introduction to Bioinformatics (10 lectures)

Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.

Unit 2

Biological databases (5 lectures)
Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (Ras Mol, J mol).

Unit 3

Data Generation and Data Retrieval (5 lectures)
Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)

Unit 4

Basic concepts of Sequence alignment (10 lectures)
Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Scoring Matrices/ Amino acid substitution matrices (PAM and BLOSUM), and CLUSTALW.

Unit 5

Phylogenetic analysis (10 lectures)
Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.

Unit 6

Applications of Bioinformatics (20 lectures)
Functional genomics (genome-wide and high throughput approaches to gene and protein function), Protein structure prediction and analysis- Levels of protein structure. gene prediction methods and tools. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.

Practical

1. Sequence retrieval (protein and gene) from NCBI.
2. Structure download (protein and DNA) from PDB.
3. Molecular file formats - FASTA, GenBank, Genpept, GCG, CLUSTAL, Swiss-Prot, FIR.
4. Molecular viewer by visualization software.
5. Translate a nucleotide sequence and select the correct reading frame of the polypeptide from the output sequences.
6. Predict the structure of protein from its amino acid sequence.
7. BLAST suite of tools for pairwise alignment.
8. Sequence homology and Gene annotation.
9. Construction of phylogenetic tree.

10. Generating phylogenetic tree using PHYLIP.
11. Gene prediction using GENSCAN and GLIMMER.

References

1. Ghosh, Z., Mallick, B. (2008). *Bioinformatics – Principles and Applications*, 1st edition. New Delhi, Delhi: Oxford University Press.
2. Baxevanis, A.D. and Ouellette, B.F., John (2005). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*, 3rd edition. New Jersey, U.S.: Wiley & Sons, Inc.
3. Roy, D. (2009). *Bioinformatics*, 1st edition. New Delhi, Delhi: Narosa Publishing House.
4. Andreas, D., Baxevanis, B.F., Francis, Ouellette. (2004). *Bioinformatics: A practical guide to the analysis of genes and proteins*, 3rd edition. New Jersey, U.S.: John Wiley and Sons.

Additional Resources:

1. Pevsner J. (2009). *Bioinformatics and Functional Genomics*, 2nd edition. New Jersey, U.S.: Wiley Blackwell.
2. Xiong J. (2006). *Essential Bioinformatics,*1st edition. Cambridge, U.K.: Cambridge University Press.

Teaching Learning Process

Multimedia tutorials and hands on training over biological data using world wide web services.
Interactive classroom teaching of mathematical modelings and Computer programs.
Weekly Lesson Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit VI
Week 14: Unit VI
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Assessment Methods

Theoretical tests with the help of assignments, project works, presentations, and through practical examinations.

Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests,
Unit II:	Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (Ras Mol, J mol).	Class room lectures and Practical demonstration, experiments, generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit III:	Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit IV:	Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Scoring Matrices/ Amino acid substitution matrices (PAM and	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests

	BLOSUM), and CLUSTALW.		
Unit V:	Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit VI:	Functional genomics (genome-wide and high throughput approaches to gene and protein function), Protein structure prediction and analysis- Levels of protein structure. gene prediction methods and tools. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests

Keywords

Biological Databases, Sequence Alignment, Phylogenetics Analysis, Protein Structure prediction and analysis.

Biostatistics
(BHDS2)
Discipline Specific Elective - (DSE) Credit:6

Course Objective(2-3)

To have knowledge of analysis of scientific data

Course Learning Outcomes

Understanding of interpreting the scientific data that is generated during scientific experiments. It is the responsibility of biostatisticians and other experts to consider the variables in subjects to understand them, and to make sense of different sources of variation. In essence, the goal of biostatistics is to disentangle the data received and make valid inferences that can be used to solve problems in public health. Biostatistics uses the application of statistical methods to conduct research in the areas of biology, public health, and medicine. Many times, experts in biostatistics collaborate with other scientists and researchers.

Unit 1

Biostatistics - definition - statistical methods - basic principles. Variables -measurements, functions, limitations and uses ofstatistics. (8 lectures)

Unit 2

Collection of data primary and secondary - types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data – sampling methods. (12 lectures)

Unit 3

Measures of central tendency - mean, median, mode, merits & demerits of harmonic and geometric mean - . Measures of dispersion - range, standard deviation, mean deviation, standard error, skewness and kurtosis, quartile deviation –merits and demerits; Co- efficient of variations. (13 lectures)

Unit 4

Correlation - types and methods of correlation, regression, simple regression equation,

fitting prediction, similarities and dissimilarities of correlation and regression.
(10 lectures)

Unit 5

Statistical inference - hypothesis - simple hypothesis - student't' test - chi square test, Ftest.
(10 lectures)

Unit 6

Basic concept of probability, Introduction to bionomial, poisson and Normal distribution; Uses of advance softwares (MS-excel, SPSS, Sigmaplot and R) in modern biostatistics. (6 Lectures)

Practical

1) Classification - tabulation and presentation of data
2) Calculation of mean, mode, median, standard deviation, quartile deviation, standard error and coefficient of variance
3) Calculation of correlation coefficient values by Karl Pearson's and Spearman Rank methods
4) Statistical inference - hypothesis – student 't' test - chi square test
5) Addition and multiple rules of probability
6) One way analysis of variance
7) Uses of software in biostatistics

References

1. Bishop, O.N., (1967). *Statistics for Biology*. Boston, Massachusetts: Houghton Mifflin Company.
2. Campbell, R.C. (1998). *Statistics for Biologists*. Cambridge, U.S.A.: Cambridge University Press.
3. Danniel, W.W. (1987). *Biostatistic*. New York,NY: John Wiley Sons.
4. Freedman, P. (1949). *The Principles of scientific research*. New York, NY: Pergamon Press.
5. Khan, I.A., Khanum, A. (2004). *Fundamentals of Biostatistics*, 5th edition. Hyderabad: Ukaaz publications.

Additional Resources:

6. Pandey, M. (2015). *Biostatistics Basic and Advanced*. New Delhi, Delhi: M V Learning.

7. Selvin, S., (1991). *Statistical Analysis of epidemiological data*. New York, NY: New York University Press.

8. Sundarrao, P.S.S., Richards, (1996). *An introduction to Biostatistics*, 3rd edition. Vellore, Tamil Nadu: J. Christian Medical College.

9. Zar, J.H. (2012). *Biostatistical Analysis*, 4th edition. London, London: Pearson Publication.

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
The students are asked to submit their record notebooks to the teacher/s for checking.
Weekly Plan
Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit VI
Week 14: Unit VI

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and

communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.
Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Biostatistics - definition - statistical methods - basic principles. Variables -measurements, functions, limitations and uses ofstatistics.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Collection of data primary and secondary - types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data – sampling methods.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Measures of central tendency - mean, median, mode, merits & demerits of harmonic and geometric mean - . Measures of dispersion - range, standard deviation, mean deviation, standard error, skewness and kurtosis, quartile deviation –merits and demerits; Co- efficient of variations.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Correlation - types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Statistical inference - hypothesis - simple hypothesis - student’t’ test - chi square test, Ftest.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Basic concept of probability, Introduction to bionomial, poisson and Normal distribution; Uses of advance softwares (MS-excel, SPSS, Sigmaplot and R) in modern biostatistics.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Biological database, Sequence database, ,NCBI, Sequence alignment, melecular Phylogeny QSAR, crop improvement ,

Industrial and Environmental Microbiology
(BHDS3)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

1. To introduce students with the industrial microbiology: concepts, principles, scope and application
2. To introduce students with the environmental microbiology: concepts, principles, scope and application

Course Learning Outcomes

Upon successful completion of the course, students are expected to be able to:

1. Understand how microbiology is applied in manufacturing of industrial products
2. Know about design of bioreactors, factors affecting growth and production
3. Understand the rationale in medium formulation & design for microbial fermentation, sterilization of medium and air
4. Comprehend the different types of fermentation processes
5. Comprehend the techniques and the underlying principles in upstream and down- stream processing
6. Learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection
7. Understand various biogeochemical cycles – Carbon and Nitrogen, and microbes involved
8. Understand the basic principles of environment microbiology and application of the same in solving environmental problems – waste water treatment and bioremediation
9. Comprehend the various methods to determine the quality of water

Unit 1

Scope of microbes in industry and environment; institutes of microbial research (4 lectures)

Unit 2

Bioreactors/Fermenters and fermentation processes (12 lectures)

Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous Fermentations; Components of a typical bioreactor, Types of bioreactors: laboratory, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Unit 3

Microbial production of industrial products (14 lectures)
Microorganisms involved, microorganisms generally regarded as safe (GRAS), media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; production of industrially important products: enzyme (amylase); organic acid (citric acid); alcohol (ethanol); antibiotic (penicillin)

Unit 4

Microbial enzymes of industrial interest and enzyme immobilization (8 lectures)
Overview of enzymes used for industrial applications, Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes: glucose isomerase and penicillin acylase

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Unit 5

Microbes and quality of environment. (6 lectures)
Distribution of microbes in air, soil and water; isolation of microorganisms from soil, air and water.

Unit 6

Microbial flora of water. (10 lectures)
Water pollution: various sources and control measures; role of microbes in sewage and domestic waste water treatment systems. Microorganisms as indicators of water quality: coliforms and fecal coliforms.

Practical

1. Principles and functioning of instruments in microbiology laboratory (autoclave, laminar air flow, incubators, types of fermenters)
2. Preparation of different culture media (Nutrient medium/ Luria Bertani medium/Potato dextrose medium/Czapek Dox medium)

3. Hydrolysis of casein / starch by microorganisms
4. Alcohol production by yeast using sugar/ jaggery
5. Serial dilution method for isolation of microorganisms from water and soil and study of aeromicroflora.
6. Determination of BOD, COD, TDS and TOC of water samples
7. Determination of coliforms in water samples using eosin methylene blue (EMB) medium
8. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations and a report to be submitted.

References

Suggested Readings

1. Pelczar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition
3. Peter F Stanbury, Allan Whitaker, Stephen J Hall, (2000). *Principles of Fermentation Technology* **.** Oxford: Butterworth-Heinemann,
4. Patel, A.H. (2011). Industrial Microbiology, New Delhi: Laxmi Publications,
5. PK Mohapatra, (2008). *Textbook of Environmental Microbiology*. New Delhi, IK International.
6. Jean-Claude Bertrand, Pierre Caumette, Philippe Lebaron, Robert Matheron, Philippe Normand, Télesphore Sime-Ngando.(2015). *Environmental Microbiology: Fundamentals and Applications,* UK:Springer

Additional Resources:

1. Cassida, L.E.. (1968). *Industrial Microbiology*, New Jersey: John Wiley & Sons
2. Atlas, R.M., Bartha, R. (1998), Microbial Ecology, Tx: USA, Benjamin / Cummings Publishing Company.
3. Sharma, P.D. (2005). *Environmental Microbiology*, Meerut: Rastogi Publications

Teaching Learning Process

i) The acquired knowledge in the classroom will be integrated with practical classes to impart a sound understanding of the course
ii) More emphasis on hands on practical sessions
iii) Visits to various research institutes/industries to understand the application of microbes for commercial productions.

iv)Visits to industries/ research institutions working towards mitigation of various environmental issues through microbial application.

v) Students will be motivated to become self-directed learners by being able to monitor and adjust their approach towards learning of the course.

Teaching Learning Plan

Week 1: Unit I Week 2: Unit I Week 3: Unit II Week 4: Unit II Week 5: Unit III Week 6: Unit III Week 7: Unit III Week 8: Unit IV Week 9: Unit IV Week 10: Mid semester Exam Week 11: Mid Semester Break Week 12: Unit V Week 13: Unit VI Week 14: Unit VI Week 15: Unit VII

Assessment Methods

i. Continuous evaluation of the progress of students
ii. Field based projects/reports
iii. Interactive sessions/ presentations
iv. Semester end evaluation

ASSESSMENT METHOD

Unit No	Coure learning Outcome	Teaching and Learning Activity	Assessment Task
I	**Scope of microbes in industry and environment**	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
II	**Bioreactors/Fermenters and fermentation processes** Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous Fermentations; Components of a typical bioreactor, Types of bioreactors: laboratory, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.	Class room lectures and Practical demonstration, experiments, industry/institute visit to learn the structure and functioning of various fermenters	Hands on excercises, PPT, assignments, tests, Industry/ institute visit report
III	**Microbial production of industrial products** Microorganisms involved, microorganisms generally regarded as safe (GRAS), media, fermentation conditions, downstream processing	Class room lectures and Practical demonstration, experiments, industry/institute visit to learn the role of	Hands on excercises, PPT, assignments, tests, Industry/ institute visit report

	and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; production of industrially important products: enzyme (amylase); organic acid (citric acid); alcohol (ethanol); antibiotic (penicillin)	microbes in production of various products	
IV	**Microbial enzymes of industrial interest and enzyme immobilization** Overview of enzymes used for industrial applications, Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes: glucose isomerase and penicillin acylase**.**	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
V	**Microbes and quality of environment.** Distribution of microbes in air, soil and water; isolation of microorganisms from soil, air and water.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VI	**Microbial flora of water.** Water pollution: various sources and control measures; role of microbes in sewage and domestic waste water treatment systems. Microorganisms as indicators of water quality: coliforms and fecal coliforms.	Class room lectures and Practical demonstration, experiments, visit to a sewage treatment plant to observe the role of microbes	Hands on excercises, PPT, assignments, tests, field visit report
VII	**Microbes in agriculture and remediation of contaminated soils.** Biological fixation (Carbon and Nitrogen); bioremediation of contaminated soils	Class room lectures and Practical demonstration, experiments, field visit	Hands on excercises, PPT, assignments, tests, field visit report

Keywords

Industrial microbiology, environmental microbiology, microbes, bioreactors, fermenters, fermentation, upstream processing, downstream processing, microbial enzymes, enzyme immobilization, aeromicroflora, water pollution, coliform, biological fixation, bioremediation

Natural Resource Management
(BHDS9)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

To introduce the students with various Natural Resources and their management strategies.
To make them aware about the contemporary practices and efforts (national and international) in resources management.

Course Learning Outcomes

It acquaint the students with various Natural Resources- their availability, causes of depletion, conservation, sustainable utilization and their management strategies. The students will be able to evolve strategies for sustainable natural resources management. The students will also have the knowledge of national and international initiatives, and policies adopted in natural resources management.

Unit 1

Natural resources (2 lectures)
Definition and types.

Unit 2

Sustainable utilization (8 lectures)
Concept, approaches (economic, ecological and socio-cultural).

Unit 3

Land (8 lectures)
Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation (magnitude of problem and cause) and management strategies; Restoration of degraded lands.

Unit 4

Water (8 lectures)
Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies, Ramsar convention.

Unit 5

Biological Resources (12 lectures)

Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).

Unit 6

Forests (6 lectures)
Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion, Biological Invasion; Management.

Unit 7

Energy (6 lectures)
Renewable and non-renewable sources of energy

Unit 8

Contemporary practices in resource management (8 lectures)
EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management.

Unit 9

National and international efforts in resource management and conservation (4 lectures)

Practical

1. Estimation of solid waste generated by a domestic system (biodegradable and non biodegradable) and its impact on land degradation.
2. Analyses for pH, hardness, TDS, Alkalinity, COD and BOD of water samples from various sources.
3. Diversity indices in field based/simulation experiment.
4. Collection of data on forest cover of specific area. Measurement of dominance of woody species by DBH (diameter at breast height) method.
5. Calculation and analysis of ecological footprint (carbon footprint using UN/WWF carbon calculator).

References

1. Vasudevan, N. (2006). *Essentials of Environmental Science*. New Delhi, India: Narosa Publishing House.
2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). *Ecology, Environment and Resource Conservation*.New Delhi, India: Anamaya Publications.
3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). *An Introduction to Sustainable Development*. New Delhi, India: Prentice Hall of India Private Limited.

Teaching Learning Process

Theory: The Class room teaching are integrated with practical classes, and field visit to impart a sound understanding of the course. The theory topics are covered in lectures with the help of blackboard teaching and Power Point presentations. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s in the laboratory/field. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to use online software, graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.

College teachers can also form a group and prepare e-contents for theory as well as for practicals.

Visit is also be organised to a Natural Ecosystem, any degraded land/Restored site or any Institution/industry.

Teaching Learning Plan:

Week 1: Unit I
Week 2: Unit II
Week 3: Unit II
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit IV
Week 7: Unit V
Week 8: Unit V
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VIII
Week 14: Unit VIII
Week 15: Unit IX

Assessment Methods

Theory: The students are continuously evaluated based on a assignments/presentation and class test. The answer scripts of the test are returned to the students. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Natural Resources	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Sustainable Utilization	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Land Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation (magnitude of problem and cause) and management strategies; Restoration of degraded lands.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Water. Fresh water ; Marine; Estuarine; Wetlands; Threats and management strategies	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Biological Resources Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Forests, Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion (deforestation and biological invasion); Management	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Energy	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Contemporary practices in resource management	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IX	National and international efforts in resource management and conservation	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Land, Water, Biodiversity, Energy, Conservation, Management Strategies

Plant Breeding
(BHDS8)
Discipline Specific Elective - (DSE) Credit:6

Course Objectives

To gain knowledge on commercially important plants, their breeding systems and strategies employed for crop improvement.

Course Learning Outcomes

Student would be able to understand the experimental steps and methods involved in generating new varieties using classical and contemporary breeding practices.

Unit 1:

An introduction to Plant Breeding (10 lectures)

Introduction and objectives. Breeding systems: modes of reproduction in crop plants. **Self-incompatibility, male sterility and apomixis.**Important achievements and undesirable consequences of plant breeding.

Unit 2: Methods of crop improvement (20 lectures)
Introduction: Centers of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self-pollinated, cross pollinated and vegetatively propagated plants;, Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.

Unit 3: Quantitative inheritance (10 lectures)

Concept, mechanism, Monogenic vs polygenic Inheritance, **QTL and QTL Mapping,** Case studies in inheritance of Kernel colour in wheat, Fruit quality in tomato.

Unit 4: Inbreeding depression and heterosis (10 lectures)

History, genetic basis of inbreeding depression and heterosis; Applications.

Unit 5: Crop improvement and breeding (10 lectures)

Role of mutations; Polyploidy; Distant hybridization, **Molecular Breeding, Marker assisted selection**, Role of biotechnology in crop improvement.

Practicals (tentative species: Pea, *Brassica*, Chickpea, Wheat*)

1. Introduction to field /controlled pollinations in field and laboratory (temporal details of anthesis, anther dehiscence, stigma receptivity and pollen viability, emasculation, bagging).
2. Analysis of the breeding system of chosen crop species by calculating Pollen:Ovule Ratio
3. Calculation of Index of self-incompatibility (ISI) and Confirmation of Self-Incompatibility.
4. Study of Quantitative and qualitative characters in select crops.
6. Study of Pollinators.
7. Assessment of genetic diversity by using Molecular Markers.

References
1. Acquaah, G. (2007). *Principles of Plant Genetics & Breeding*.New Jearsey, U.S.: Blackwell Publishing.
3. Singh, B.D. (2005). *Plant Breeding: Principles and Methods*, 7th edition. New Delhi, Delhi: Kalyani Publishers.
2. Chaudhari, H.K. (1984). *Elementary Principles of Plant Breeding*, 2nd edition. New Delhi, Delhi: Oxford – IBH.

Teaching Learning Process

The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Field observation
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Field observation
Week 13: Unit V
Week 14: Unit V

Assessment Methods

The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation. The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	. **Plant Breeding I**ntroduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	**Methods of crop improvement** Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	**Quantitative inheritance, C**oncept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings.Monogenic vs polygenic Inheritance.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	**Inbreeding depression and heterosis** History, genetic basis of inbreeding depression and heterosis; Applications.		
Unit V	**Crop improvement and breeding,** Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.		

Keywords

breeding system , reproduction, pollination, domestication of plants , genetic resources, hybridization, inheritance , inbreeding depression, crop improvement

Biofertilizers
(BHSE3)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

To gain the knowledge on the following aspects

1. Eco-friendly fertilizers like Rhizobium, Azospirilium Azotobactor, cyanobacteria and mycorrhizae, their identification, growth multiplication
2. Organic farming and recycling of the organic waste

Course Learning Outcomes

The student would have a deep understanding of ecofriendly fertilizers. They will be able to understand the growth and multiplication conditions of useful microbes such as Rhizobium, cyanobacteria, mycorrhizae, Azotobacter etc, their role in mineral cycling and nutrition to plants. The can also think of the methods of decomposition of biodegradable waste and convert into the compost

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Unit 1

General account about the microbes used as biofertilizer – Rhizobium – isolation,identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis. (4 lectures)

Unit 2

Azospirillum: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms.Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication. (8 lectures)

Unit 3

Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation. (4 lectures)

Unit 4

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants. (8 lectures)

Unit 5

Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application. (6 lectures)

Practical

1. Isolation of *Anabaena* from *Azolla* leaf
2. Study of Rhizobium from root nodules of leguminous plants by Gram staining method
3. Test for pH, No2, SO4, Cl and organic matter of different composts
4. Observation of mycorrhizae from roots
5. isolation of arbuscular mycorrhizal spores from rhizospheric soil
6. Spots, Specimen /photographs of earthworm, azolla, arbuscules . vesicles
7. Biocontrol photographs -pheromons trap,Trichoderma,, Pseudomonas, , Neem etc, , Identification and application
8. Photographs of biocompost methods,
9. Projects on any topic mentioned in the syllabus, with Rhizobium technology, , AMF technology, Organicfarming, vermicomposting,, biocompost , *Azolla* culture

References

1. Dubey, R.C. (2005). *A Text book of Biotechnology*. New Delhi, Delhi: S.Chand & Co.
2. John Jothi Prakash, E. (2004). *Outlines of Plant Biotechnology*. New Delhi, Delhi: Emkay Publication.
3. Kumaresan, V. (2005). *Biotechnology*. New Delhi, Delhi: Saras Publication.
4. Sathe, T.V. (2004). *Vermiculture and Organic Farming.* New Delhi, Delhi: Daya publishers.
5. Subha Rao, N.S. (2000). *Soil Microbiology*. New Delhi, Delhi: Oxford & IBH Publishers.

Additional Resources:

6. Vayas,S.C, Vayas, S., Modi, H.A. (1998). *Bio-fertilizers and organic Farming.* Nadiad, Gujarat: Akta Prakashan.

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.

When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

strong>Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.

The students are asked to submit their record notebooks to the teacher/s for checking.

Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit III
Week 7: Field visit
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IV
Week 13: Unit V
Week 14: Unit V
Week 15: Unit V

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.

Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.

An assignment can be given in place of the presentation.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	General account about the microbes used as biofertilizer – Rhizobium – isolation,identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	*Azospirillum*: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms.Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Rhizobium, Azotobacter, inoculum, , cyanobacteria, nitrigen fixation, Azolla,VAM, mycorrhizae

Ethnobotany
(BHSE1)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

To have the knowledge of the plants used by the local communities, tribals, ethenic groups, their nutritive and medicinal value.

Course Learning Outcomes

Students would have an understanding of the treasure, value and usefulness of the the natural products and their efficient use by the local communities as food and medicine and their conservation practices .

Unit 1

Ethnobotany (6Lectures)
Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science.The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) intoxicants and beverages c) Resins and oils and miscellaneous uses.

Unit 2

Methodology of Ethnobotanical studies (6lectures)
a) Field work
b) Herbarium
c) Ancient Literature
d) Archaeological findings
e) temples and sacred places.

Unit 3

Role of ethnobotany in modern Medicine (10 lectures) Medicoethnobotanical sources in India;Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) Azadiractha indica b) Ocimum sanctum c) Vitex negundo. d) Gloriosa superba e) Tribulus terrestris f) Pongamia pinnata g) Cassia auriculata h) Indigofera tinctoria.

Unit 4

Role of ethnobotany in modern medicine with special example of *Rauvolfia sepentina, Trichopus zeylanicus, Artemisia,Withania.* Role of ethnic groups in conservation of plant genetic resources.Endangered taxa and forest management (participatory forest management).

Unit 5

Ethnobotany and legal aspects (8 lectures) Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy,

Unit 6

Intellectual Property Rights and Traditional Knowledge.

Practical

Collection , identification and preparation of herbarium of three ethenobotanically important plants with appropriate references
Preparation of crude extract of ethenobotanically important plants with appropriate references (any method to be used)
Project work-documentation, literature survey, and collection of information on ethnobotanically useful plants from traditional healers)

References

1. Colton, C.M. (1997). *Ethnobotany – Principles and applications.* Chichester, England: John Wiley and sons.
2. Faulks, P.J. (1958).*An Introduction to Ethnobotany.*London, U.K.: Moredale pub. Ltd.
3. Jain, S.K. (1995). *Manual of Ethnobotany.* Rajasthan: Scientific Publishers.
4. Jain, S.K. (1981). *Glimpses of Indian Ethnobotany.* New Delhi, Delhi: Oxford and I B H.

Additional Resources:

1. Jain, S.K. (1990). *Contributions of Indian Ethnobotany.* Jodhpur, Rajasthan: Scientific publishers.

2. Jain, S.K. (ed.) (1989). *Methods and approaches in Ethnobotany.* Lucknow, U.P.: Society of ethnobotanists.
3. Lone et al., *Palaeoethnobotany*.
4. Rama, R. N., Henry A.N. (1996). *The Ethnobotany of Eastern Ghats in Andhra Pradesh.* Howrah, West Bengal: Botanical Survey of India.

5. Sinha, R.K.(1996). *Ethnobotany The Renaissance of Traditional Herbal Medicine.* Jaipur, Rajasthan: SHREE Publishers.

Teaching Learning Process

To engage students and transform them into active learners the students are updated with latest books and review articles.
The experiments included in the paper are performed individually or in group and are followed by group discussions and interjections
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Local Field Visits
Week 6: Unit II
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Local Institute Visit
Week 14: Unit VI
Week 15: Unit VI

Assessment Methods

The students are assessed on the basis of oral presentations and regular class tests.
Students are continuously assed during practical class.
Submission of class records is mandatory. This exercise develops scientific skill as well as methods of recording and presenting scientific data.

Assessment Task

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Ethnobotany as an interdisciplinary science.The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) intoxicants and beverages	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests

	c) Resins and oils and miscellaneous uses		
Unit II:	Methodology of Ethnobotanical studies- Field work, Herbarium, Ancient Literature, Archaeological findings, temples and sacred places	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Medicoethnobotanical sources in India;Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) Azadiractha indica b) Ocimum sanctum c) Vitex negundo. d) Gloriosa superba e) Tribulus terrestris f) Pongamia pinnata g) Cassia auriculata h) Indigofera tinctoria.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Role of ethnobotany in modern medicine with special example of *Rauvolfia sepentina*, *Trichopus zeylanicus*, *Artemisia*,*Withania.* Role of ethnic groups in conservation of plant genetic resources.Endangered taxa and forest management (participatory forest management).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Ethnobotany and legal aspects (8 lectures) Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy,	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Intellectual Property Rights and Traditional Knowledge.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Tribals,.minor forest products, intoxicants, beverages, Resins, Field work, Herbarium, sacred groves,. ethnobotanical practices, Azadiractha indica, Ocimum sanctum, Vitex negundo. Gloriosa superba, Indigofera tinctoria.ethnomedicimes , conservation ,Traditional Knowledge.

Floriculture
(BHSE5)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

To have knowledge of gardening and cultivation of ornamental plants and knowledge of landscaping, soil condition.

Course Learning Outcomes

Students would be able to identify the ornamental plants, They will have an understanding of cultivation methods, landscaping and making the flower arrangement.

Unit 1

Unit 1: Introduction: History of gardening; Importance and scope of floriculture and landscape gardening. (2 Lectures)

Unit 2

Unit 2: Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading; Stopping or pinching; Defoliation; Wintering; Mulching; Topiary; Role of plant growth regulators. (8 lectures)

Unit 3

Unit 3: Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai. (4 lectures)

Unit 4

Unit 4: Principles of Garden Designs: English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India. (4 lectures)

Unit 5

Unit 5: Landscaping Places of Public Importance: Landscaping highways and Educational institutions. (4 lectures)

Unit 6

Unit 6: Commercial Floriculture: Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous, Marigold,Rose, Lilium, Orchids). (6 lectures)

Unit 7:Diseases and Pests of Ornamental Plants.**(2 lectures)**

Practical

1. Study of flower with reference to stamens and gynoecium
2. Study of Soil sterilization process
3. Seed sowing and transplantation methods
4. Garden designing and hedge preparation methods
5. patterns of flower arrangement in vase
6. study of disease and pastes of ornamental plants

References

1. Randhawa, G.S., Mukhopadhyay, A. (1986). *Floriculture in India.* New York, NY: Allied Publishers.

Teaching Learning Process

The topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Lesson Plan

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Field observation

Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VI
Week 13: Unit VI
Week 14: Unit VII

Assessment Methods

The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks
Unit wise Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	History of gardening; Importance and scope of floriculture and landscape gardening.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading; Stopping or pinching; Defoliation; Wintering; Mulching; Topiary; Role of plant growth regulators.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments,

	and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai.	experiments	tests
Unit IV:	Principles of Garden Designs: English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Landscaping Places of Public Importance: Landscaping highways and Educational institutions.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Commercial Floriculture: Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous, Marigold,Rose, Lilium, Orchids).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII	Diseases and Pests of Ornamental Plants.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Propagation methods, Gardening , transplantation,saplings,Ornamental, cacti , succulents, hedge, fencing lawns, grass, orchids

Intellectual Property Rights
(BHSE2)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

To have knowledge of roles regulations, laws and processes og patents, copyright trade marks and concepts of traditional knowledge and protection of plant varieties .

Course Learning Outcomes

Students would have deep understanding of patents copyrights, their importance. Thy can think about the importance of traditional knowledge, bio-prospecting, biopiracy. They would gain the knowledge of farmers rights and the importance on indigenous plant varieties, concept of novelty and biotechnological inventions

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Unit 1

Introduction to intellectual property right (IPR) (2 lectures)
Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples.IPR and WTO (TRIPS, WIPO).

Unit 2

Patents (3 Lectures)
Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents.Infringement.

Unit 3

Copyrights (3 Lectures)
Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement

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Unit 4

Trademarks (3 Lectures)
Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences, Domain name

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Unit 5

Geographical Indications (3 Lectures)
Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position

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Unit 6

Protection of Traditional Knowledge (4 Lectures)
Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, needfor a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library.

Unit 7: Industrial Designs (2 Lectures)
Objectives, Rights, Assignments, Infringements, Defences of Design Infringement

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Unit 8: Protection of Plant Varieties (2 Lectures)
Plant Varieties Protection- Objectives, Justification, International Position, Plant varieties protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues farmers, Breeders and Researchers.National gene bank, Benefit sharing.Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit 9:Information Technology Related Intellectual Property Rights (4 Lectures)
Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection Unit 10: Biotechnology and Intellectual Property Rights. (4 Lectures) Patenting Biotech Inventions

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Practical

1. **Patent search**
2. **Trademark search**
3. copyright infringement (Plagiorism checkby Urkundand other available software,
4. Geographical Indicators (i) food- Malabar pepper, Basmati rice, Darjeeling Tea, and Requefort cheese, handlooms, (Kota Doria, , Banarasi Sari, , Muga Silk, Kanchipuram), II- Industry (Mysore agarbatti, Feni Goa, Champagne, (France). IV. Natural resources- (Makrana marbles Two example of each category
5. Biopiracy-neem , turmeric
6. Industrial designs- Jewellery design, chair design, car design, Bottle design, Aircraft design,
7. IPR e diary

References

1. N.K., Acharya.(2001).Text Book on Intellectual Property Rights: (Copyright, Trademark, Patent Design, Geographical Indications, Protection of New Plant Varieties & Farmers Rights and Protection of Biodiversity).
2. S.P. Gogia. *On Intellectual Property Rights (IPR)*. Hyderabad: Asia Law House.
3. M.K. Bhandari (2017). *Law Relating to Intellectual Property Rights (IPR).* Allahabad: U.P.: Central Law Publications.

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.

When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.

The students are asked to submit their record notebooks to the teacher/s for checking

Week 2: Unit II
Week 3: Unit III
Week 4: Unit IV
Week 5: Unit V
Week 6: Unit VI
Week 7: Unit VI
Week 8: Unit VII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit IX
Week 14: Unit IX
Week 15: Unit X

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.

Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples.IPR and WTO (TRIPS, WIPO).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents.Infringement.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Copyrights (3 Lectures) Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences, Domain name	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Geographical Indications, Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, needfor a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	Industrial Designs Rights, Assignments, Infringements, Defences of Design Infringement	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Plant Varieties Protection- Objectives, Justification, International Position, Plant varieties protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues farmers, Breeders and	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	Researchers.National gene bank, Benefit sharing.Protection of Plant Varieties and Farmers' Rights Act, 2001.		
Unit IX:	Information Technology Related Intellectual Property Rights Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X	Biotechnology and Intellectual Property Rights. Patenting Biotech Inventions	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Keywords

Patents, IPR, Copyrights,trademarks, geographical indicators, traditional knowledge, industrial design, plant varieties , novelty, biotechnology

Medicinal Botany
(BHSE4)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

- To introduce students to complementary and alternative medicine and provide them an opportunity
- To explore uses of plants as medicine ranging from traditional indigenous approach for treating ailments to modern pharmaceuticals
- To inculcate awareness about the rich diversity of medicinal plants in India.

Course Learning Outcomes

Knowledge Skills

- An appreciation of the contribution of medicinal plants to traditional and modern medicine and the importance of holistic mode of treatment of the Indian traditional systems of medicine.
- To develop an understanding of the constraints in promotion and marketing of medicinal plants.

Professional and Practical Skills

- Transforming the knowledge into skills for promotion of traditional medicine.
- Developing entrepreneurship skills to establish value addition products, botanical extracts and isolation of bioactive compounds.

Unit 1

Scope and importance of medicinal plants in the traditional systems of medicine and modern medicine.Importance of preventive and holistic healing in theIndian traditional systems of medicine.Ayurveda: History, origin, fundamental doctrine and concepts of Panchamahabhutas, Saptadhatus andTridoshasin relation to health and disease.

Unit 2

Therapeutic and pharmaceutical uses of important plants used in the Ayurveda system of medicine. Concept of Rasayanadrugs.Siddha :

Origin, concepts, therapeutic and pharmaceutical uses of important plants used in Siddha system of medicine.Unani : History, concept of Umoor-e-Tabiya(Fundamentals of Physique), therapeutic and pharmaceutical uses of plants used in Unani system of medicine

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Unit 3

Nutraceuticals and polyherbalformulations. Plants used for the treatment of hepatic disorders, cardiac diseases,infertility, diabetes, blood pressure, cancer and skin diseases.Role of AYUSH, NMPB and AIIA in thepromotion of medicinal plants.

Unit 4

Adulteration of herbal drugs.Evaluation and Standardization of crude drugs.Fundamentals of Pharmacognosy. Organoleptic,microscopicand phytochemical evaluation of plant drugs.

Unit 5

Conservation of Endangered and Endemic Medicinal plants.Red Data List Criteria. In-situ Conservation : Biosphere Reserves, National Parks, Sacred Groves. Ex-situ conservation :Botanic Gardens, National Gene Banks, Plant cell, tissue, and Organ culture, Cryopreservation. Role of NBPGR, CIMAP, JNTBGRI and RRL.

Unit 6

General aspects of cultivation and propagation of medicinal plants. WHO Guidelines of Good Agricultural and Cultivation Practices (GACP). Objectives of the Nursery,classification and important components ofnursery. Greenhouse technology. Propagation through cuttings, layering, grafting and budding.

Practical

1. Identification and medicinal value of locally available medicinal plants in the field.
2. Study of organoleptic, macroscopic and microscopic parameters of any two plant drugs. Sections and powder microscopic evaluation.
3. Isolation of bioactive compounds in the lab and phytochemical analysis of the crude extract of various parts of medicinal plants.
4. Study of ingredients and medicinal uses of common polyherbal formulations used in the traditional systems of medicine.
5. Project Report based onvisit to PharmaceuticalIndustries and/or Institutes.
6. E-presentations : Traditional Systems of Medicine, Contribution of medicinal plants toalternative and modern medicine, Conservation strategies of medicinal plants,Nutraceuticals, Rasayana drugs, Medicinal plants and non-communicable diseases, Cultivation, marketing and utilisation of medicinal plants.
7. Laboratory Records

References

1. Chaudhry, B. (2019). *A Handbook of Common Medicinal Plants Used in Ayurveda.* Kojo Press, New Delhi.
2. Purohit, Vyas (2008). *Medicinal Plant Cultivation : A Scientific Approach*, 2nd edition. Jodhpur, Rajasthan: Agrobios.
3. S.B. Gokhale, C.K. Kokate (2009). *Practical Pharmacognosy.* Pune, Maharashtra: Nirali Prakashan.
4. Trivedi, P.C. (2006). *Medicinal Plants Traditional Knowledge.* New Delhi, Delhi: I.K. International Publishing House Pvt. Ltd.

Additional Resources:

1. Trivedi, P.C. (2009). *Medicinal Plants. Utilisation and Conservation.* Jaipur, Rajasthan: Aavishkar Publishers.

2.William C. E. (2010). *Trease and Evans's Pharmacognosy,* 16th edition. Philadelphia, Pennsylvania: Saunders Ltd.

Teaching Learning Process

- To encourage innovation, to link theoretical knowledge with practical training and application of knowledge to find practical solutions to the challenges encountered in the field of traditional medicine.
- To hold regular and structured workshops, seminars, field trips, collaboration with Research institutions, Industry and other Government Organizations, in order to facilitate peer learning and skill enhancement.
- To complement classroom teaching with discussions, presentations, quizzes,interpretation of results, short projects, writing project reports and field exposure.

Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit III
Week 7: Field visit
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit V
Week 14: Unit VI
Week 15: Unit VI

Assessment Methods

Continuous Evaluation
(Project/ E-presentation :10 marks, Lab Records :
Attendance in Practicals
Practical Examination :

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Scope and importance of medicinal plants in the traditional systems of medicine and modern medicine.Importance of preventive and holistic healing in theIndian traditional systems of medicine.Ayurveda : History, origin, fundamental doctrine and concepts of Panchamahabhutas, Saptadhatus andTridoshasin relation to health and disease.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Therapeutic and pharmaceutical uses of important plants used in the Ayurveda system of medicine. Concept of	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments,

	Rasayanadrugs. Siddha : Origin, concepts, therapeutic and pharmaceutical uses of important plants used in Siddha system of medicine.Unani : History, concept of Umoor-e-Tabiya(Fundamentals of Physique), therapeutic and pharmaceutical uses of plants used in Unani system of medicine	experiments	tests
Unit III:	Nutraceuticals and polyherbalformulations. Plants used for the treatment of hepatic disorders, cardiac diseases,infertility, diabetes, blood pressure, cancer and skin diseases.Role of AYUSH, NMPB and AIIA in thepromotion of medicinal plants.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Adulteration of herbal drugs. Evaluation and Standardization of crude drugs. Fundamentals of Pharmacognosy. Organoleptic,microscopicand phytochemical evaluation of plant drugs.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Conservation of Endangered and Endemic Medicinal plants. Red Data List Criteria. In-situ Conservation : Biosphere Reserves, National Parks, Sacred Groves. Ex-situ conservation :Botanic Gardens, National Gene Banks, Plant cell, tissue, and Organ culture, Cryopreservation. Role of NBPGR, CIMAP, JNTBGRI and RRL.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	General aspects of cultivation and propagation of medicinal plants. WHO Guidelines of Good Agricultural and Cultivation Practices (GACP). Objectives of the Nursery,classification and important components ofnursery. Greenhouse technology. Propagation through cuttings, layering, grafting and budding	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Keywords :Medicinal plants, Ayurveda, Siddha, Unani,Holistic healing, Phytochemicals, Pharmacognosy, Polyherbals, Conservation, Propagation.

Mushroom Culture Technology
(BHSE8)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

Objective of this paper to make aware student about the mushroom growing techniques.
Mushrooms have medicinal and nutritional value students will be make aware of that.
National and international market that helps in economy of country students will be make aware about this also as this is low cost input process but benefits/outcomes are high.

Course Learning Outcomes

As mushroom cultivation is a booming field Goverment of India is also supporting this type of work because students can learn the techniques and small scale and large scale industries can be established by the students. Hand on experience will be given to students so they can utilize this training in long run. In small area also they can establish the bussiness..

Unit 1

Introduction, history, Nutritional and medicinal value of edible mushrooms, Poisonous mushrooms, Types of edible mushrooms availablein India: *Volvariella,Volvacea , Pleurotus citrinopileatus, Agaricus bisporus.*

Unit 2

Cultivation technology,Infrastructure substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculationloop, low cost stove, sieves, culture rack, mushroomunit (Thatched house) water sprayer, tray, small polythene bags, Pure culture, Medium psterlization , preperation spawn, multiplication, mushroom bed preperation, paddy straw, sugarcane trash, maize straw, banana leaves, Factors affecting the mushroom bed preperation -- low cost technology, compostingtechnology in mushroom production.

Unit 3

Storage and nutrition,short term storage (Refrigeration upto 24 hours) long term storage (canning, pickels and papads) drying, storage in salt solutions, . Nutrition- proteins, amino acids, mineral elements nutrition- carbohydrates, crude fibre content- vitamins.

Unit 4

Food preperation , Types of food prepared from mushroom. Research centers-- National level and Regional level ,, Cost benefit ratio-- Marketing in India and abroad, Export value.

Practical

1. Principle and functioning of instruments used in the various techniques.
2. Preperation of various types of media.
3. Preperation of spawn.
4. Study of poisnous and non poisonous mushroom
5. Study of diseases of mushroom.
6. Nutritional and market value of mushroom
7. Centres of mushroom
8. Techniques for the cultivation of *Agaricus* , *Pleurotus and Ganoderma*
9. *Visit to Institute and* cultivation centre.

References

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan, R. (1991) Oyster Mushrooms,Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan , M. (1990) Food and Nutrition. Bappco, The Banglore Printing and Publishing Co. LTD, No. 88, Mysore Road, Banglore- 560018.
3. Tewari, Pankaj Kappor, S.C.(1998) Mushroom cultivation, Mittal Publications , Delhi.
4. Nita Bahi (1984-1988) Hand book of Mushrooms, II Edition, vol. I& II.

Teaching Learning Process

Classroom knowledge of the student will be integrated with hand on experience/practical to make understanding strong. Practicals are designed on hand on experience basis.
Visit to Institutes and farm houses will make understanding and awareness better of students.
Students will be motivated to start their start up in this field. Group discussions , test, assignments and power point presentations will be there.

Teaching Learnig Plan

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit II
Week 6: Unit II
Week 7: Unit III
Week 8: Unit II
Week 9: Unit III
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit III
Week 13: Unit IV
Week 14: Unit IV
Week 15: Unit IV

Assessment method

Unit No	Coure learning Outcome	Teaching and Learning Activity	Assessment Task
I	Introduction, history, Nutritional and medicinal value of edible mushrooms, poisonous mushrooms. Types of edible mushrooms available in India- *Volvariella voivacea, Pleurotus citrinopileatus, Agaricus bisporus*	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests &Viva voce
II	Cultivation technology, Infra structure substrates (locally available) Polythene bag vessels,Inoculation hook, loop, low cost stove, sieves, culture rack, mushroom unit , (Thatched house) water sprayer, tray, small polythene bag, pure culture, medium sterilization, preparation of spawn, multiplication, Mushroom bed preparation, paddy straw, sugarcane trash,maize straw, banana leaves, Factors affecting the bed preparation,- low cost technology, composting technology in mushroom production	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests & viva voce
III	Storsage and nutrition, short term storage (Refrigeration – upto 24 hours) . Long term storage (canning, pickels ,papads) drying , storagein salt solutions. Nutrition- proteins, amino acids, mineral elements nutrition- carbohydrates, crude fibre content- vitamins.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
IV	Food prepration, Types of food prepared from mushroom, Research centres- National level and Regional level , cost benefit raio – Marketing in Indiaand Abroad, Export value.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests

Assessment Methods

Field based projects will be there regarding growing of various types of mushrooms related to environmental conditions. Field report will be there regarding the visit. Power point presentations. Continuous evaluation of the student.

Keywords

Mushroom cultivation, spawning, culture, media straw paddy , maize polythene bags, trays, soil, dung, casing, *Agaricus, Pleurotus, Volvariella*

Nursery and Gardening
(BHSE7)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To gain knowledge of gardening , cultivation, multiplication , raising of seedlings of ornamental plants

Course Learning Outcomes

Students would have an understanding of
How nursery of the plants is prepared?
How rooting is promoted in the stem cuttings?
How seeds are stored and what are the soil conditions for seed sowing and seedling growth?
How landscaping is designed?

Unit 1

Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.(4 Lectures)

Unit 2

Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion - Seed production technology - seed testing and certification. (6 Lectures)

Unit 3

Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants - green house - mist chamber, shed root, shade house and glass house. (6Lectures)

Unit 4

Gardening: definition, objectives and scope - different types of gardening - landscape and home gardening - parks and its components - plant materials and design - computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting. (8 Lectures)

Unit 5

Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady’s finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures. **(6 Lectures)**

Practical

1. Breaking of seed dormancy
2. Seed viability tests
3. Preparation of stem cutting, air layering
4. soil layering and manuring
5. compost preparation
6. Diseases and pests of plants

References

1. Agrawal, P.K. (1993). *Hand Book of Seed Technology*. New Delhi, Delhi: Dept. of Agriculture and Cooperation, National Seed Corporation Ltd.
2. Bose T.K., Mukherjee, D. (1972). *Gardening in India*. New Delhi, Delhi: Oxford & IBH Publishing Co.
3. Jules, J. (1979). *Horticultural Science*, 3rd edition. San Francisco, California: W.H. Freeman and Co.
4. Kumar, N. (1997). *Introduction to Horticulture*. Nagercoil, Tamil Nadu: Rajalakshmi Publications.

Additional Resources:

1. Musser E., Andres. (2005). *Fundamentals of Horticulture*. New Delhi, Delhi: McGraw Hill Book Co.
2.Sandhu, M.K. (1989). *Plant Propagation*. Madras, Bangalore: Wile Eastern Ltd.

Teaching Learning Process

Teaching session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.. Field visits and institutional visits will alo be included

The students are asked to submit their record notebooks to the teacher/s for checking.

Weekly Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Field observation
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Field observation
Week 13: Unit V
Week 14: Unit V

Assessment Methods

The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the students will listen to the presentation of each student, and they are also encouraged to ask questions. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions. An assignment can be given in place of the presentation

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion - Seed production technology - seed testing and certification.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants - green house - mist chamber, shed root, shade house and glass house.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Gardening: definition, objectives and scope - different types of gardening - landscape and home gardening - parks and its components - plant materials and design - computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Transplantation seed dormancy, seed viability, vegetative propagation,layring , cutting , rooting medium, hardening , landscaping

Plant Diversity and Human welfare
(BHSE9)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective(2-3)

To gain the knowledge of
1. biodiversity and its importance.
2. Agricultural diversity
3. biodiversity loss and biodiversity management

Course Learning Outcomes

The students would be able to judge the value of biodiversity and its role in stabilizing the climate and economy. They would know the causes and consequences of loss of biodiversity and planning of conservation strategies. .

Unit 1

Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at theecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity:Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes. (8 lectures)

Unit 2

Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss, **Management of Plant Biodiversity:** Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication. (8 lectures)

Unit 3

Conservation of Biodiversity: Conservation of genetic diversity, speciesdiversity and ecosystem diversity, *In situ* and *ex situ* conservation, Socialapproaches to conservation, Biodiversity awareness programmes, Sustainable development. (8 lectures)

Unit 4

Role of plants in relation to Human Welfare; a) Importance of forestry their utilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d) Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses. (6 lectures)

Practical

1. Mapping species diversity
2. mapping of crop diversity
3. Visits of plant conservatories
4. study of wood features
5. Herbarium study of a.Avenue trees,b) Ornamental plantsc Fruits and nuts: Important fruit crops. Wood

References

1. Krishnamurthy, K.V. (2004). *An Advanced Text Book of Biodiversity - Principles and Practices.* New Delhi, Delhi: Oxford and IBH Publications Co. Pvt. Ltd.

Teaching Learning Process

Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking. Field visits will also be arranged

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Field observation
Week 6: Unit III
Week 7: Unit III
Week 8: Unit III
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Field observation
Week 13: Unit IV
Week 14: Unit IV

Assessment Methods

The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the students listen to the presentation of each student, and they will be encouraged to ask questions. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, new information has been added, and lastly on the answers given by students to the questions.

Unit wise Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at theecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity:Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss, Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Conservation of genetic diversity, species diversity and ecosystem diversity, *In situ* and *ex situ* conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	a) Importance of forestry their utilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d) Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Genetic diversity, species diversity, crop diversity , biodiversity loss,crop diversity ,value of diversity, IUCN, UNEP, UNESCO, WWF, NBPGR;
Biodiversity legislation, conservation, forestry, fruits, timber

Biodiversity (Microbes, Fungi, Algae and Archegoniates)
(BHGE1)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

Biodiversity generally refers to the variety and variability of life on earth. Plants are relevant to humans as they provide us with food, shelter, clothing, energy, health, aesthetic beauty, environment and even economy. This paper is relevant to ALL students.

1. Introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi, to various plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms).
2. Information on the Ecological and Economic Importance of Microbes, Fungi and various plant groups to enable students understand and appreciate relevance of Microbes and Plants to environment and human well-being.
3. Insight into the line of Plant Evolution on Earth and the consequent Biodiversity is instrumental in creating Awareness on the threats to biodiversity and sensitize young minds towards the Biodiversity Conservation for sustainable development.

Course Learning Outcomes

1. Combination of Theoretical and Practical components will provide comprehensive information and insight into the fascinating world of Microbes and Plants.
2. Hands on Training will help students learn use of microscope, mounting, section-cutting and staining techniques for the study of plant materials.
3. Making Drawings in Practical Records will enhance understanding morphological and structural details and related functional aspects in diverse plant groups.
4. Use of Illustrations, Photographs, Charts, Permanent Slides, Museum and Herbarium Specimens along with ICT Methods will provide an interesting insight into the beautiful world of microbes and plants.
5. Scope of Biodiversity includes Medicinal field, Industry, Agriculture, Research and Study, Job Opportunities and Environmental Conservation. This paper is both informative and interesting and will enable students to learn about Biodiversity not only as a plant or nature lover, but also for higher academic pursuits, particularly in the field of Biological Sciences, Environment and Biodiversity Conservation.

Unit 1

MICROBES (14 Lectures)

a) **Viruses** – Discovery; General Structure- RNA virus (TMV) and DNA virus (T-phage); Replication-Lytic and Lysogenic Cycle; Economic Importance.
b) **Bacteria** – Discovery; General Characteristics and Cell Structure; Reproduction-Vegetative, Asexual and Genetic Recombination (Conjugation, Transformation and Transduction); Economic Importance.

Unit 2

FUNGI (8 Lectures)

General Characteristics; Outline Classification (Webster); Economic Importance; Thallus Organization and Reproduction in *Rhizopus*, *Penicillium*, *Alternaria* and *Puccinia*.

Unit 3

ALGAE (8 Lectures)

General Characteristics; Outline Classification (Fritsch); Economic Importance; Thallus Organization and Reproduction in *Nostoc*, *Chlamydomonas*, *Vaucheria* and *Ectocarpus*.

Unit 4

ARCHEGONIATAE(30 Lectures)

a) **Bryophytes (10 Lectures)**

General Characteristics; Outline Classification; Ecological and Economic Importance; Morphology, Structure and Reproduction in Marchantia, Anthoceros and Funaria.

b) **Pteridophytes (10 Lectures)**

General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Selaginella*, *Equisetum* and *Pteris*.

c) **Gymnosperms (10 Lectures)**

General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Cycas* and *Pinus*.

Practical

1. **Viruses-** Structure of TMV and T-Phage (EMs/ Models/ Photographs); Lytic and Lysogenic Cycle (Line Drawings/ Photographs).
2. **Bacteria**-Types and Structure (Permanent Slides/ Photographs); EM Bacterium; Binary Fission and Conjugation (Photographs).
3. ***Rhizopus***, ***Penicillium*** and ***Alternaria***- Asexual Stage from Temporary/ Tease Mounts, ***Puccinia***-Black Stem Rust of Wheat and Infected Barberry Leaves (Herbarium Specimens/ Photographs), Tease Mounts of Spores on Wheat, Section of infected portion of Wheat and Barberry (Permanent Slides).
4. ***Chlamydomonas***-E.M., ***Nostoc***, ***Vaucheria*** and ***Ectocarpus***- Study of Vegetative and Reproductive Structures through Temporary Preparations and Permanent Slides.
5. **Bryophytes :*Marchantia***-Morphology of Thallus, W.M. Rhizoids, V.S. Thallus through Gemma Cup, W.M. Gemma (all Temporary Slides), L.S. Sporophyte (Permanent slide).

Anthoceros- Morphology of Thallus, W.M. Rhizoids, L.S./ T.S. Capsule, W.M. Spores, W.M. Pseudoelaters, (all Temporary Slides), L.S. Sporophyte (Permanent slide).***Funaria***- Morphology of Gametophyte bearing Sporophyte, W.M. Rhizoids, W.M. Leaf, W.M. Operculum, W.M. Peristome, W.M. Spores (all Temporary Slides), L.S. Capsule (Permanent Slide).

6. **Pteridophytes: *Selaginella***- Morphology, T.S. Stem, W.M. Strobilus, W.M. Microsporophyll and Megasporophyll (all Temporary Slides), L.S. Strobilus (Permanent Slide).

   Equisetum- Morphology, T.S. Stem (Internode), L.S./ T.S. Strobilus, W.M. Sporangiophore, W.M. Spores (Wet and Dry) (all Temporary Slides).

   Pteris- Morphology, V.S. Sporophyll, W.M. Sporangium, W.M. Spores (all Temporary Slides), W.M. Prothallus with Sex Organs (Permanent Slide).

7. **Gymnosperms: *Cycas***- Morphology (Coralloid Roots, Leaf, Microsporophyll, Megasporophyll), T.S. Coralloid Root (Permanent Slide), V.S. Leaflet, V.S. Microsporophyll, W.M. Spores (all Temporary Slides), L.S. Ovule (Permanent Slide). ***Pinus***- Morphology (Long and Dwarf Shoots, Male and Female Cones), W.M. Dwarf Shoot, T.S. Needle, L.S/ T.S. Male Cone, W.M. Microsporophyll, W.M. Microspores (all Temporary Slides), L.S Female Cone (Permanent Slide).

References

1. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). *Introductory Mycology*. Singapore, Singapore: John Wiley and Sons (Asia).
2. Fritsch, F.E. (1965). *The Structure and Reproduction of the Algae. Vol.1, 2*. Cambridge: Cambridge University Press.
3. Kaur, I..D., Uniyal, P.L. (2019).*Text Book of Gymnosperms*. New Delhi,ND: Daya Publishing House,
4. Parihar, N.S. (1972). *An Introduction to Embryophyta. Vol. II: Pteridophyta*. Allahabad, UP: Central Book depot.

Additional Resources:

1. Bhatnagar, S.P., Moitra, A. (1996). *Gymnosperms*. New Delhi, ND: New Age International (P) Ltd Publishers.
2. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2008). *Biology*. San Francisco, SF: Pearson Benjamin Cummings.
3. Kumar, H.D. (1999). *Introductory Phycology*. New Delhi,Delhi: Affiliated East-West. Press Pvt. Ltd.
4. Parihar, N.S. (1991). *An Introduction to Embryophyta. Vol. I. Bryophyta*. Allahabad, UP: Central Book Depot.
5. Puri, P. (1985) *Bryophytes*. New Delhi, Delhi. Atma Ram and Sons, Delhi

6. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). *Biology*. New Delhi, Delhi: Tata McGraw Hill.
7. Singh, V., Pandey, P.C., Jain, D.K. (2001). *A text Book of Botany*. Meerut, UP: Rastogi and Co.
8. Tortora, G.J., Funke, B.R., Case, C.L. (2010). *Microbiology: An Introduction*. San Francisco, SF: Pearson Benjamin Cummings.
9. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). *Botany For Degree Students Pteridophyta*. New Delhi, Delhi: S. Chand Publication.
10. Vashistha, B.R., Sinha, A.K., Kumar, A. (2011). *Botany For Degree Students, Bryophyta*. New Delhi, Delhi: S Chand Publication.
11. Webster, J. and Weber, R. (2007). *Introduction to Fungi*. Cambridge, Cambridge University Press.

Teaching Learning Process

THEORY:

1. The theory topics are covered in lectures with the help of both conventional (chalk board) and modern (ICT) methods, including use of Charts.
2. Emphasis is on interactive class room environment so as to encourage students ask questions/ doubts/ queries for clarification/explanation and discussion.
3. Students are encouraged to refer to reference books in library to inculcate reading habit for better grasp and understanding on the subject.
4. Emphasis is given to illustrations- neat, well-labelled outline and cellular diagrams/ flowcharts for improving creative skills and to substantiate the text content.
5. On completion of theory syllabus, previous years' question papers are discussed so as to apprise students about the general format of semester exam question papers.
6. Assignment (10), Test (10) and Theory Attendance (5) are components of Internal Assessment Scheme for compilation of Internal Assessment Score of each student out of 25 marks.

PRACTICAL:

1. Every practical session begins with instructions, followed by students doing table work for detailed microscopic plant study.
2. Plant study is done using fixed plant materials, museum and herbarium specimens, photographs and permanent slides.
3. The students are instructed about maintaining practical records, which includes comments and diagrams.
4. Students are asked to submit practical records regularly, on a continuous basis, for checking.
5. On completion of practical syllabus, Practical Exam Guidelines are discussed to apprise students about the formant of Practical exam.
6. As part of Continuous Evaluation guidelines, total score for each student is calculated out of 25 marks, taking into consideration Practical Records (10), Practical Test/ Assessment (10) and Practical Attendance (5)Teaching Learning Plan

Week 1: Unit I

Week 2: Unit I
Week 3: Unit I
Week 4: Unit I
Week 5: Unit II
Week 6: Unit II
Week 7: Unit III
Week 8: Unit III
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IV
Week 13: Unit IV
Week 14: Unit IV
Week 15: Unit IV
Week 16: Unit IV

Assessment Methods

THEORY:

1. Emphasis is given for an interactive classroom environment, with at least few minutes for question-answer session.
2. Assignment topics are given to students for submission of hand written assignments.
3. Test is taken, with both objective and descriptive questions, from a defined portion of syllabus.
4. Assignment (10), Test (10) and Theory Attendance (5) are components of Internal Assessment Scheme for compilation of Internal Assessment Score of each student out of 25 marks.

PRACTICAL:

1. Students are monitored in the practical class w.r.t their performance in table work for detailed plant study.
2. Students are asked to submit practical records regularly, on a continuous basis, for checking.
3. Emphasis is given on neat, labelled diagrams and proper, concise comments in practical records, with properly maintained Index page regularly signed by the teacher.
4. Practical Test/ Assessment is taken to evaluate students performance as per guidelines framed for Continuous Evaluation under C.B.C.S.
5. As part of Continuous Evaluation guidelines, total score for each student is calculated out of 25 marks, taking into consideration Practical Records (10), Practical Test/ Assessment (10) and Practical Attendance (5).

Assessment Method

Unit No		Teaching and Learning Activity	Assessment Task
I	**MICROBES (14 Lectures)** a) **Viruses(7Lectures)** – Discovery; General Structure- RNA virus (TMV) and DNA virus (T-	Class room Lectures	Hands on

	phage); Replication-Lytic and Lysogenic Cycle; Economic Importance. b) **Bacteria (7Lectures)** – Discovery; General Characteristics and Cell Structure; Reproduction- Vegetative, Asexual and Genetic Recombination (Conjugation, Transformation and Transduction); Economic Importance.	and Practical demonstration, Photographs Class room Lectures and Practical demonstration, Photographs, Experiments	excercises, Assignments, Tests Hands on excercises, Assignments, Tests
II	**FUNGI (8 Lectures)** General Characteristics; Outline Classification (Webster); Economic Importance; Thallus Organization and Reproduction in *Rhizopus*, *Penicillium*, *Alternaria* and *Puccinia*.	Class room Lectures and Practical demonstration, Type Study	Hands on excercises, Assignments, Tests
III	**ALGAE (8 Lectures)** General Characteristics; Outline Classification (Fritsch); Economic Importance; Thallus Organization and Reproduction in *Nostoc*, *Chlamydomonas*, *Vaucheria* and *Ectocarpus*.	Class room Lectures and Practical demonstration, Type Study	Hands on excercises, Assignments, Tests
IV	**ARCHEGONIATAE(30 Lectures)** a) **Bryophytes (10 Lectures)** General Characteristics; Outline Classification; Ecological and Economic Importance; Morphology, Structure andReproduction in *Marchantia*, *Anthoceros*and *Funaria*. b) **Pteridophytes (10 Lectures)** General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Selaginella*, *Equisetum* and *Pteris*. c) **Gymnosperms (10 Lectures)** General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Cycas* and *Pinus*.	Class room Lectures and Practical demonstration, Type Study	Hands on excercises, Assignments, Tests

Keywords

Biodiversity; Microbes; Viruses; Bacteria; Fungi; Algae; Archegoniates; Bryophytes; Pteridophytes; Gymnosperms

Economic Botany and Biotechnology
(BHGE7)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

To gain the knowledge on the economically important of plants, their life cycle, processing, plant part used, application of biotechnology for the production of plant resources and production of new varieties

Course Learning Outcomes

Understanding of morphology,and processing and economic value of plant sources of cereals, legumes,spices, oil,rubber, timber and medicines

Unit 1

Origin of Cultivated Plants (4 lectures)

Concept of centres of origin, their importance with reference to Vavilov's work.

Unit 2

Cereals (4lectures):

Wheat -Origin, morphology, uses

Unit 3

Legumes (6 lectures)

General account with special reference to Gram and soybean

Unit 4

Spices (6 lectures)

General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)

Unit 5

Beverages (4 lectures)

Tea (morphology, processing, uses)

Unit 6

Oils and Fats (4lectures)

General description with special reference to groundnut

Unit 7

Fibre Yielding Plants (4lectures)

General 4description with special reference to Cotton (Botanical name, family, part used,morphology and uses)

Unit 8

Introduction to Plant Biotechnology (1 lecture)

Unit 9

Tissue Culture Tchnology (9 lectures)

Introduction; nutrient media; aseptic and culture conditions; developmental pathways: direct and indirect organogenesis and embryogenesis; single cell and protoplast culture.

Unit 10

Recombinant Technology (18 lectures)

Molecular techniques: Blotting techniques (Southern, Northern and Western); PCR; Molecular DNA markers (RAPD, RFLP, SNPs) and DNA fingerprinting in plants.

Genetic Engineering Techniques: Gene cloning vectors (pUC 18, pBR322, BAC, YAC, Ti plasmid); construction of genomic and C-DNA libraries; screening for gene of interest by DNA probe hybridisation, complementation; Insertion of genes into plant tissues (*Agrobacterium* mediated, electroporation, micro-projectile bombardment); selection of recombinants by selectable marker and reporter genes (GUS, luciferase, GFP). Applications: Bt cotton, Roundup ready soybean, Golden rice, Flavr-Savr tomato, edible vaccines, industrial enzyme production, Bioreactors, Applications: Micropropagation, androgenesis, gynogenesis, embryo and endosperm culture, secondary metabolite production, germplasm conservation.

Practical

1. Study of economically important plants : Wheat, Gram, Soybean, Black pepper, Clove Tea, Cotton, Groundnut through specimens, sections and microchemical tests
2. Familiarization with basic equipments in tissue culture.
3. Study through photographs: Anther culture, somatic embryogenesis, endosperm and embryo culture; micropropagation.
4. Study of molecular techniques: PCR, Blotting techniques, AGE and PAGE.

References

1. Bhojwani, S.S., Razdan, M.K. (1996). *Plant Tissue Culture: Theory and Practice*. Amsterdam, Netherlands: Elsevier Science.

2. Glick, B.R., Pasternak, J.J. (2003). *Molecular Biotechnology- Principles and Applications*. Washington, U.S.: ASM Press.

Additional Resources:

1. Kochhar, S.L. (2011). *Economic Botany in the Tropics*, 4th edition. New Delhi, Delhi: MacMillan Publishers India Ltd.

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
The students are asked to submit their record notebooks to the teacher/s for checking.
Week 2: Unit II
Week 3: Unit III
Week 4: Unit IV
Week 5: Unit V
Week 6: Unit VI
Week 7: Unit VII
Week 8: Unit VII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IX
Week 13: Unit X
Week 14: Unit X
Week 15: Unit X

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Concept of centres of origin, their importance with reference to Vavilov's work.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Cereals : Wheat -Origin, morphology, uses	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Legumes, general account with special reference to Gram and soybean	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Spices ,general account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Beverages, Tea (morphology, processing, uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Oils and Fats, general description with special reference to groundnut	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	General 4description with special reference to Cotton (Botanical name, family, part used,morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Introduction to Plant Biotechnology	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Nutrient media; aseptic and culture conditions; developmental pathways: direct and indirect organogenesis and embryogenesis; single cell and protoplast culture.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Unit X:	Molecular techniques: Blotting techniques (Southern, Northern and Western); PCR; Molecular DNA markers (RAPD, RFLP, SNPs) and DNA fingerprinting in plants.Gene cloning vectors (pUC 18, pBR322, BAC, YAC, Ti plasmid); construction of genomic and C-DNA libraries; screening for gene of interest by DNA probe hybridisation, complementation; Insertion of genes into plant tissues (*Agrobacterium* mediated, electroporation, micro-projectile bombardment); selection of recombinants by selectable marker and reporter genes (GUS, luciferase, GFP). Applications: Bt cotton, Roundup ready soybean, Golden rice, Flavr-Savr tomato, edible vaccines, industrial enzyme production, Bioreactors Micropropagation, androgenesis, gynogenesis, embryo and endosperm culture, secondary metabolite production, germplasm conservation.	Class room lectures and Practical demonstration, experiments	exercises, PPT, assignments, tests

Keywords

Vavilove, Cultivated plants, , Wheat, Gram , soyabean, spices, Tea, cotton, groundnut, tissue culture, recombinant DNA technology, Molecular markers, RAPD, PCR, ELISA.

Environmental Biotechnology
(BHGE6)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

This course aims to introduce the students to various regional and global concerns regarding the environment, including the natural challenges, various types of environmental contaminants and their sources and effects, environmental changes, and the developments of diverse technologies to detect, study and address these concerns. The course aims to introduce the specific roles of chemical, biological and molecular sciences to identify and address the emerging environmental issues.

Course Learning Outcomes

1. Explain the various global and regional environmental concerns due to natural causes and/or human activities.
2. Investigate some examples of different types of environmental pollution and their impacts.
3. Describe existing and emerging technologies that are important in the area of environmental biotechnology.
4. Demonstrate an awareness of emerging concerns such as climate change, waste management or reductions in fossil fuels, and new technologies for addressing these.
5. Appreciate the scientific, ethical and/or social issues associated with certain applications of biotechnology for alleviating the environmental concerns.
6. Explain national and international legislations, policies and role of public participation in Environmental Protection
7. Students will have an insight on the causes and consequences of environmental pollution, pollutants, They can think about the prevent of degradation of environment and management of pollutants.

Unit 1

Environment - basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management. **(4 lectures)**

Unit 2

An overview of atmosphere, hydrosphere, lithosphere and anthrosphere - environmental problems.Environmental pollution - types of pollution, sources of pollution, measurement of pollution, methods of measurement of pollution, fate of pollutants in the environment, Bioconcentration, bio/geomagnification. **(6 lectures)**

Unit 3

Microbiology of waste water treatment, aerobic process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic process - anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industries. (8 lectures)

Unit 4

Xenobiotic compounds - organic (chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants) and inorganic (metals, radionuclides, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, decay behavior and degradative plasmids, molecular techniques in bioremediation. **(10 lectures)**

Unit 5

Role of immobilized cells/enzymes in treatment of toxic compounds. Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control. **(6 lectures)**

Unit 6

Sustainable Development: Economics and Environment: Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and cost effectiveness analysis, WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics. **(8 lectures)**

Unit 7:

International Legislations, Policies for Environmental Protection: Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Basel Convention (1989), Kyoto Protocol-1997, Ramsar Convention 1971. **(6 lectures)**

Unit 8

National Legislations, Policies for Pollution Management: Salient features of Wild life protection act 1972, Water Pollution (Prevention and Control) Act-1974, Forest conservation act 1980, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy - 2006, Central and State Pollution Control Boards: Constitution and power. **(6 lectures)**

Unit 9

Public Participation for Environmental Protection: Environmental movement and people’s participation with special references to Gandhamardan, Chilika and Narmada Bachao Andolan, Chipko and Silent valley Movement; Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society. **(6 lectures**

Practical

1. To determine the pH and total hardness of water samples collected from different places (polluted and non-polluted sites).
2. To determine the salinity of water samples (polluted and non-polluted sites)
3. To determine the dissolved oxygen of two water samples
4. To determine alkalinity of water samples.
5. To determine pH and rapid field test of soil samples (Calcium, Magnesium, Nitrate and Chloride).
6. Set-ups- through photograph

    i. Microbial assessment of air (open air plate) and water)
    ii. Interaction of plant seeds with diesel for potential use in remediation of diesel fuel from contaminated soil.
    iii. Growth response of Bacteria on Petroleum Fuel.
    iv. Isolation and characterization of Bacteria from crude petroleum oil contaminated soil.

References

1.Allsopp D., Seal K.J., ELBS/ Edward Arnold. (2004). *Introduction to Biodeterioration.* Cambridge, U.K.: Cambridge University Press.
2. Tchobanoglous, G. (2005). *Waste water engineering - treatment, disposal and reuse*. New Delhi, Delhi: Metcalf, Eddy Inc., Tata McGraw Hill.
3.Trivedi. P.C. (2006).*Biodiversity Assessment and Conservation*. Jodhpur, Rajasthan: Agrobios.
4. Baaker, K.H., Herson, D.S. (1994). *Bioremidation.* NewYork, NY: Mc.Graw Hill Inc.

Additional Resources:

1. De. A.K. (1994).*Environmental Chemistry.* New Delhi, Delhi: Wiley Eastern Ltd.
2.Jadhav S., Bhosale, V.M. (1995). *Environmental Protection and Laws.* New Delhi, Delhi: Himalaya publication House.
3. Nuzhat, A., Fouad M., Qureshi,K. (2006). *Industrial and Environmental Biotechnology.* Muzaffarnagar, U.P.: Horizon Press.
4. Paul, A. R. (2001). *Environmental Molecular Biology.* Muzaffarnagar, U.P.: Horizon Press.

Teaching Learning Process

To engage students and transform them into active learners the students are updated with latest books and review articles.The experiments included in the paper are performed individually or in group and are followed by group discussions and interjections.
Week 2: Unit II
Week 3: Unit III
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit IV

Week 7: Unit V
Week 8: Unit V
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VIII
Week 14: Unit VIII
Week 15: Unit IX

Assessment Methods

The students are assessed on the basis of oral presentations and regular class tests.

- Students are continuously assed during practical class.
- Submission of class records is mandatory. This exercise develops scientific skill as well as methods of recording and presenting scientific data.

Assessment Task

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Environment - basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	An overview of atmosphere, hydrosphere, lithosphere and anthrosphere - environmental problems.Environmental pollution - types of pollution, sources of pollution, measurement of pollution, methods of measurement of pollution, fate of pollutants in the environment, Bioconcentration, bio/geomagnification.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Microbiology of waste water treatment, aerobic process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic process -anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industries.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Organic (chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants) and inorganic (metals, radionuclides, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, decay behavior and	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	degradative plasmids, molecular techniques in bioremediation.		
Unit V:	Role of immobilized cells/enzymes in treatment of toxic compounds. Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Economics and Environment: Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and cost effectiveness analysis, WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	Policies for Environmental Protection: Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Basel Convention (1989), Kyoto Protocol- 1997, Ramsar Convention 1971.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Policies for Pollution Management: Salient features of Wild life protection act 1972, Water Pollution (Prevention and Control) Act-1974, Forest conservation act 1980, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy - 2006, Central and State Pollution Control Boards: Constitution and power.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Public Participation for Environmental Protection: Environmental movement and people's participation with special references to Gandhamardan, Chilika and Narmada Bachao Andolan, Chipko and Silent valley Movement; Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Green house effect, anthropogenic activity, pollutants, bioconcentration, geomagnification, Aerobic process, activated sludge, oxidation ponds, oxidation ditch. anaerobic digestion, anaerobic sludge blanket reactors. Water Treatment schemes .metals, bioremediation, biobleaching , policies on environment protection, public movements. contaminants, waste management, xenobiotic compounds, biopesticides, polyaromatic hydrocarbons, biosensors, bio-techniques, Stockholm Conference, Brundtland Report (1987), Ramsar convention 1971.

Plant Anatomy and Embryology
(BHGE2)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

The Objective of this paper is to provide basic knowledge of plant internal architecture and cellular composition and reproduction.This help them to understand how different plant tissue structure evolve and modify their functions with respect to their environment.

Course Learning Outcomes

Knowledge regarding anatomy equipped the students to identify different types of tissues and make them able to correlate their physiology in a better away.This will also help them to understand how different plant tissue evolve and modify their structure and functions with respect to their environment. Knowledge regarding embryology make them understand how reproduction play significant role in defining population structure, natural diversity and sustainability of ecosystem in a better way.

Unit 1

Meristematic and permanent tissues (8 lectures)
Simple (parenchyma, collenchyma, sclerenchyma) and complex tissues (xylem, phloem), Root and shoot apical meristems (describe theories in brief with special reference to Tunica Corpus and Korper-Kappe theory)

Unit 2

Organs (4 lectures)
Structure of dicot and monocot root stem and leaf.

Unit 3

Secondary Growth (8 lectures)
Vascular cambium: structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood)

Unit 4

Adaptive and protective systems (8 lectures)

Epidermis (trichomes and hair), cuticle, stomata: structure and type (Metcalf and Chalk Classification); General account of adaptations in xerophytes and hydrophytes (Examples may be cited from *Nerium*, *Opuntia*, *Hydrilla* and *Nymphaea*).

Unit 5

Introduction to Reproduction (5 lectures)

Modes of reproduction in plants: vegetative options - natural and artificial; introduction and Significance of sexual reproduction.

Unit 6

Structural organization of flower (10 lectures)

Organization of flower, Structure; Anther and Pollen (No developmental stage); Ovules: Structure and types; Embryo sac: Types special reference to Polygonum type.

Unit 7

Pollination and fertilization (10 lectures)

Pollination mechanisms and adaptations; Double fertilization and triple fusion; Seed: Structure (Dicot and Monocot, No developmental stages) appendages and dispersal mechanisms.

Unit 8

Embryo and endosperm (10 lectures)

Endosperm types (one example of each type), structure and functions; Dicot and Monocot embryo; Embryo endosperm relationship (General account).

Practical

1. Study of meristems through permanent slides and photographs.
2.Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem: Monocot: *Zea mays;* Dicot: *Helianthus*.
4. Root: Monocot: *Zea mays*; Dicot: *Helianthus*.
5. Leaf: Dicot and Monocot (only Permanent slides).
6. Adaptive anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Hydrilla* stem).
7. Structure of anther (young and mature).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac (Permanent slides/photographs).
11. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) Photographs/specimens).
12. Dissection of embryo/endosperm from developing seeds.
13. Calculation of percentage of germinated pollen in a given medium.

References

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas. Publication House Pvt. Ltd. New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
3.Raven P. et al. Biology of plants Seventh edition (2005). W. H. Freeman, New York

Additional Resources:

1. Dickison,W.C.(2000).Integrated Plant anatomy .Academic press Inc.
2. Fahn, A. (1982).Plant anatomy.Pergamon Press, Oxford.

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
Teaching Learning Plan

Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit IV
Week 7: Unit V
Week 8: Unit VI
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VII
Week 14: Unit VIII
Week 15: Unit VIII

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.

Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.

An assignment can be given in place of the presentation.

The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment method

Unit No	Coure learning Outcome	Teaching and Learning Activity	Assessment Task
I	Meristematic and permanent tissues: Simple (parenchyma, collenchyma, sclerenchyma) and complex tissues (xylem, phloem), Root and shoot apical meristems (describe theories in brief with special reference to Tunica Corpus and Korper-Kappe theory)	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
II	Organs: Structure of dicot and monocot root stem and leaf.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
III	Secondary Growth: Vascular cambium: structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood)	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
IV	Adaptive and protective systems: Epidermis (trichomes and hair), cuticle, stomata: structure and type (Metcalf and Chalk Classification) ; General account of adaptations in xerophytes and hydrophytes (Examples may be cited from *Nerium, Opuntia, Hydrilla* and *Nymphaea*).	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests

V	Introduction to Reproduction: Modes of reproduction in plants: vegetative options - natural and artificial; introduction and Significance of sexual reproduction.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VI	Structural organization of flower: Organization of flower, Structure; Anther and Pollen (No developmental stage); Ovules: Structure and types; Embryo sac: Types special reference to Polygonum type.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VII	Pollination and fertilization: Pollination mechanisms and adaptations; Double fertilization and triple fusion; Seed: Structure (Dicot and Monocot, No developmental stages) appendages and dispersal mechanisms.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VIII	Embryo and endosperm: Endosperm types (one example of each type), structure and functions; Dicot and Monocot embryo; Embryo endosperm relationship (General account).	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests

Keywords

meristem, secondary growth, Vascular cambium, anther, embryo sac, pollination, double fertilisation, endosperm, reproductive biology.

Plant Ecology and Taxonomy
(BHGE3)
Generic Elective - (GE) Credit:6

Course Objective(2-3)

Objectives: To make students understand ecology and basic ecological concepts, inter-relation between the living world and environment. Also to make them aware about identification, nomenclature and classification.

Course Learning Outcomes

After successful completion of the course the student shall have adequate knowledge about the basic principals of environment and taxonomy.

Unit 1

Introduction (1 lecture)

Inter-relation between the living world and environment

Unit 2

Ecological factors (11 lectures)

Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance.

Unit 3

Plant communities (6 lectures)

Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)

Unit 4

Ecosystem (8 lectures)

Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous

Unit 5

Phytogeography (4 lectures)

Principle biogeographical zones; Endemism (definition and types)

Unit 6

Introduction to plant taxonomy (1 lecture)

Identification, Classification, Nomenclature.

Unit 7

Identification (5 lectures)

Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access

Unit 8

Taxonomic evidences from palynology, cytology, phytochemistry and molecular data. (6 lectures)

Unit 9

Taxonomic hierarchy (2 lectures)

Ranks, categories and taxonomic groups

Unit 10

Botanical nomenclature (6 lectures)

Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit 11

Classification (6 lectures)

Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (up to series).

Unit 12

Biometrics, numerical taxonomy and cladistics (4 lectures)

Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

Practical

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer, hygrometer, rain gauge and lux meter.
2. Determination of pH, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.

3 (a) Study of morphological adaptations of hydrophytes and xerophytes (four each).

(b)Study of biotic interactions of the following: Stem parasite (Cuscuta), Root parasite (Orobanche), Epiphytes, Predation (Insectivorous plants)

4. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. \(species to be listed)

5. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law

6. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):Brassicaceae - Brassica,Alyssum / Iberis; Asteraceae - Sonchus/Launaea, Vernonia/Ageratum,Eclipta/Tridax; Solanaceae -Solanum nigrum, Withania; Lamiaceae -Salvia, Ocimum; Liliaceae - Asphodelus / Lilium / Allium.

7. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted on the herbarium sheet with appropriate label.)

References

1. Kormondy, E.J. (1996). Concepts of Ecology.Prentice Hall, U.S.A. 4th edition.
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
3. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
4. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi

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Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and talk and chalk method. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Week 1: Unit I and part of II
Week 2: Unit II
Week 3: Unit II
Week 4: Unit III
Week 5: Unit III and part of IV
Week 6: Unit IV
Week 7: Unit V
Week 8: Unit V
Week 9: Unit VI and part of VII
Week 10: Unit VII and VIII
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit IX and X
Week 14: Unit XI
Week 15: Unit XII

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
The students are asked to submit their record notebooks to the teacher/s for checking and evaluation

Assessment Methods

Theory: The students are continuously evaluated based on a written assignment, class test and/or presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a Assignment/PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation. The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Unit No	Core learning Outcome	Teaching and Learning Activity	Assessment Task
I	Inter-relation between the living world and environment	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
II	Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
III	Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
IV	Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling;	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests

	Cycling of carbon, nitrogen and Phosphorous		
V	Principle biogeographical zones; Endemism (definition and types)	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VI	Identification, Classification, Nomenclature	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VII	Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
VIII	Taxonomic evidences from palynology, cytology, phytochemistry and molecular data	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
IX	Taxonomic hierarchy: Ranks, categories and taxonomic groups	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
X	Botanical nomenclature: Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
XI	Classification: Types of classification- artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (up to series).	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests
XII	Biometrics, numerical taxonomy and cladistics: Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).	Class room lectures and Practical demonstration, experiments	Hands on excercises, PPT, assignments, tests

Keywords

Environment, Soil, Water, Plant communities, Succession, Ecosystem, Phytogeography, Endemism, Plant taxonomy, Taxonomic hierarchy, Botanical Nomenclature, Classification, Biometrics

Plant Physiology and Metabolism
(BHGE5)
Generic Elective - (GE) Credit:6

Course Objective (2-3)

The course aims at making students realize how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology.

Course Learning Outcomes

The students are able to correlate morphology, anatomy, cell structure and biochemistry with plant functioning. The link between theory and practical syllabus is established, and the employability of youth would be enhanced. The youth can also begin small-scale enterprises.

Unit 1

Plant-water relations **(8 Lectures)**

Importance of water, water potential and its components, pathway of water movement, ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation, stomatal movements – only ion theory.

Unit 2

Mineral nutrition **(8 Lectures)**

Essential elements, macro- and micronutrients, criteria of essentiality of elements, methods of studying mineral requirement (Hydroponics, Aeroponics), role of essential elements, transport of ions across membrane, active and passive transport, carriers, channels and pumps.

Unit 3

Translocation in phloem **(6 lectures)**

Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading.

Unit 4

Photosynthesis **(10 Lectures)**

Historical contribution of Julius von Sachs, Blackman, Emerson, Engelmann, Hill. Arnon; photosynthetic pigments (chlorophyll a and b, xanthophyll, carotene); photosystem I and II, reaction centre, antenna molecules; electron transport and mechanism of ATP synthesis, C3 pathway; C4 and CAM plants (in brief, no pathways); photorespiration.

Unit 5

Respiration **(6 Lectures)**

Glycolysis, anaerobic respiration, TCA cycle, oxidative phosphorylation, glyoxylate cycle, RQ.

Unit 6

Enzymes **(4 Lectures)**

Structure and properties, Km (no derivation), mechanism of enzyme catalysis and enzyme inhibition.

Unit 7

Nitrogen metabolism **(6 Lectures)**

Biological nitrogen fixation - nodulation in detail, nitrate and ammonia assimilation, dinitrogenase, NR, NiR, transamination.

Unit 8

Plant growth regulators **(6 Lectures)**

Discovery, physiological roles of auxins, gibberellins, cytokinins and ethylene.

Unit 9

Plant response to light and temperature **(6 Lectures)**

Photoperiodism - discovery (SDP, LDP, day neutral plants); phytochrome (discovery and structure), red and far-red light response on photomorphogenesis (general account), florigen (brief account).

***NO STRUCTURES AND FORMULAE TO BE ASKED IN THE EXAM**

Practical

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of the environmental factor light on transpiration by excised twig.
3.Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. To Study Hill's reaction.
5. To study the activity of catalase and study the effect of pH and enzyme concentration.
6. To study the effect of light intensity on O2evolution in photosynthesis.
7. Comparison of the rate of respiration in any two parts of a plant.

Demonstration experiments

1. Bolting.
2. Effect of auxins on rooting.

3. Suction due to transpiration.
4. Hydroponics (using a photograph).
5. To demonstrate the delay of senescence by cytokinins.
6. To study the phenomenon of seed germination (effect of light and darkness)

References

1. Bajracharya, D. (1999). *Experiments in Plant Physiology: A Laboratory Manual.* New Delhi, Delhi: Narosa Publishing House.
2. Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism.* Singapore: Springer Nature, Singapore Pvt. Ltd.
3. Hopkins, W. G., Huner, N. P. A. (2009). *Introduction to Plant Physiology*, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd.
4. Kochhar, S.L., Gujral, S.K. (2017). *Plant Physiology: Theory and Applications.* New Delhi, Delhi: Foundation Books, imprint of Cambridge University Press India Pvt, Ltd.

Additional Resources:

1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). *Plant Physiology and Development International*, 6th edition. New York, NY: Oxford University Press,Sinauer Associates.

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
The students are asked to submit their record notebooks to the teacher/s for checking.
Weekly lesson Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit III
Week 4: Unit IV
Week 5: Field observation
Week 6: Unit V
Week 7: Unit VI
Week 8: Unit VII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break

Week 12: Unit VIII
Week 13: Unit IX
Week 14: Unit IX

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
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Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Importance of water, water potential and its components, pathway of water movement, ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation, stomatal movements – only ion theory..	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Essential elements, macro- and micronutrients, criteria of essentiality of elements, methods of studying mineral requirement (Hydroponics, Aeroponics), role of essential elements, transport of ions across membrane, active and passive transport, carriers, channels and pumps.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Historical contribution of Julius von Sachs,	Class room lectures	Hands on

	Blackman, Emerson, Engelmann, Hill. Arnon; photosynthetic pigments (chlorophyll a and b, xanthophyll, carotene); photosystem I and II, reaction centre, antenna molecules; electron transport and mechanism of ATP synthesis, C3 pathway; C4 and CAM plants (in brief, no pathways); photorespiration	and Practical demonstration, experiments	exercises, PPT, assignments, tests
Unit V	Glycolysis, anaerobic respiration, TCA cycle, oxidative phosphorylation, glyoxylate cycle, RQ.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI	Structure and properties, Km (no derivation), mechanism of enzyme catalysis and enzyme inhibition.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII	Biological nitrogen fixation - nodulation in detail, nitrate and ammonia assimilation, dinitrogenase, NR, NiR, transamination.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII	Discovery, physiological roles of auxins, gibberellins, cytokinins and ethylene.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	Photoperiodism - discovery (SDP, LDP, day neutral plants); phytochrome (discovery and structure), red and far-red light response on photomorphogenesis (general account), florigen (brief account)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Movement of water, ascent of sap, transpiration, stomatal movements, mineral nutrients, active and passive transport, translocation, plant growth regulators, photoperiodism, photomorphogenesis

ACKNOWLEDGEMENTS

This work would not have been possible without the help by the Undergraduate Curriculum Committee, who time to time prvided the academic as well as technical guidance during the revision of the courses.

I am especially indebted to Professor K. S. Rao, Head, department of Botany, University of Delhi, who worked actively to provide me with the academic time to pursue the goal of course revision.

I am grateful to all of those with whom I have had the pleasure to work. Each of the convinors and members of working group has provided me extensive personal and professional guidance in the improvement of the contents of the syllabi of Botany programmes. I would especially like to thank Dr. Anuradha Sharma, Hindu College, Dr Vijay Kumar, Shivaji College and Atika Chandra, Maitryie College, who have greatly contributed in the preparation of the course revision groups, preparation of the framework and writing substantial part of the course outcome. Besides that I especially thank the following members who have been more important to me in the pursuit of this project by working as convenors and working members for the revision of the courses of Botany programmes

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8. Dr Roshni Rajamohan, Deshbandhu College
9. Dr Kalyani Krishnan, Sri Venkateshwara College
10. Dr Rajni Gupta, Kirorimal College
11. Dr Meenam Bhatia, Daulat Ram College
12. Dr Neeru Bhandari, Dyal Singh College
13. Dr Vijaya Rani Rajpal, Hansraj College
14. Dr Dharmendra Mallick, Deshbandhu College
15. Dr Surinder Kaur, SGTB Khalsa College
16. Dr Inderdeep Kaur, SGTB Khalsa College
17. Dr Bharti Chaudhry, Ramjas College
18. Dr Rashni Mathur, Sri Aurobindo College
19. Dr D. Monika Ram, Hindu College
20. Dr S N Tripathi, Deen Dayal Upaddhyay College
21. Dr Anjana Sagar, SGTB Khalsa College
22. Dr Suman Sharma, Ramjas College

23. Dr Archana Singh, Hansraj College
24. Dr Kumar Shantanu, Deshbandhu College
25. Dr Anand Sonkar, Hansraj College
26. Dr Bhupender Giri, Swami Shraddhanand College
27. Dr Priyanka Pandey (nee) Kapoor, Gargi College
28. Dr Shukla Saluja, Sri Venkateshwara College
29. Aparna Nautiyal, Deshbandhu College, University of Delhi
30. Jasleen Kaur Kalia, Dyal Singh College
31. Dr Varnika Bhatia Deen Dayal Upaddhyay College
32. Dr Monika Koul, Hansraj College
33. Dr Sudesh Bhardwaj, Kalindi College
34. Dr Saloni Bahari, Miranda House
35. Dr Mohammad Wahid Anisari, Zakir Husain Delhi College
36. Dr Savindra Chatwal, Zakr Husain Delhi College
37. Dr Smita Tripathi, Shivaji College
38. Dr Somdatta Sinha, Miranda House
39. Dr Savita Singh, Hindu College

Prem L Uniyal
(Professor and Coordinator,
Botany Programmes)

दिल्ली विश्वविद्यालय

UNIVERSITY OF DELHI

B. Sc. (Hons.) Zoology

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Applicable for students registered with Regular Colleges, Non-Collegiate, Women's Education Board and School of Open Learning

Table of Content

Preamble

The objective of any program at Higher Education Institute is to prepare their students for the society at large. The University of Delhi envisions all its programmes in the best interest of their students and in this endeavour; it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programs.

The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the program of their choice. The Under-Graduate Programs will prepare the students for both, academia and employability.

Each program vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The program also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each program prepares students for sustainability and life-long learning.

The University of Delhi hopes the LOCF approach of the program B.Sc. (Hons.) Zoology will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

1. Introduction

The learning outcomes-based curriculum framework for B.Sc. degree in Zoology is structured to offer a broad outline within which a Zoology program could be developed. The course is upgraded keeping in mind the aspirations of students, changing nature of the subject as well as the learning environment. Courses within Zoology have been revisited to incorporate recent advancements, techniques to upgrade the skills of learners. The new structure is expected to enhance the level of understanding among students and maintain the standard of Zoology degrees/program across the country. Effort has been made to integrate use of recent technology and use of MOOCs to assist teaching-learning process among students. This framework permits the review of graduate attributes, qualification descriptors, program learning outcomes and course-level learning outcomes periodically. The framework offers flexibility and innovation in syllabi designing and in methods adopted for teaching- learning process and learning assessment. The major objective is to elevate the subject knowledge of the students, making them critical thinkers and able to solve problems and issues related to Zoology logically and efficiently. Overall, this course has been modified to upgrade skills related to biological science and provide our students a competitive edge in securing a career in academia, industry, pharmaceutical research and development in private as well as public sectors.

2. Learning Outcome-based Curriculum Framework

2.1 Nature and Extent of the Program

Zoology is broad subject encompassing classical and modern systemic aspects of animal diversity, as well as contemporary subjects like Molecular Biology, Bioinformatics, Biotechnology and Medical Diagnostics to foster comprehensive understanding about various aspects of animal science. The scope of Zoology as a subject is wide-ranging. The major areas of study within the discipline of Zoology are: Diversity of Non-chordates and Chordates; Comparative Anatomy of Vertebrates; Cell Biology; Biochemistry; Molecular Biology; Evolutionary Biology; Principles of Genetics; Principles of Ecology and Physiology. Diversity of Non-chordates and Chordates deals with the classification and adaptive diversity of animals from diverse phyla; Comparative Anatomy of Vertebrates deals with structural comparisons among all vertebrates; Cell Biology deals with the study of structure and functions of the cell; Biochemistry deals with the study of chemical substances and vital processes occurring within the living organisms; Molecular Biology deals with the nature of biological phenomena at the molecular level; Evolutionary Biology studies the evolutionary processes that produced the diversity of life on Earth, starting from a single common ancestor; Principles of Genetics deals with the molecular structure and function of genes, and gene behavior in context of a cell or organism; Principles of Ecology studies the structure and function of nature; Physiologydeals with the functions and activities of life or of living matter (such as organs, tissues, or cells) and of the physical and chemical phenomena involved. Degree program in Zoology deals with other topics that overlap with the areas outlined above (Immunology; Parasitology; Basics of Neurosciences; Animal Behavior and Chronobiology; Animal Biotechnology; Agrochemicals and Pest Management; Biology of Insecta; Endocrinology; Computational Biology; Fish and Fisheries; Reproductive Biology and Wildlife Conservation and Management); and that address the topics related to applied fields (such as Apiculture; Aquarium Fish Keeping; Medical Diagnostics; Research Methodology and Sericulture). The applied topics include visits to industries, fields or commercial culture units to get in-depth knowledge of the subject and also to explore employment opportunities in the field. In addition, some interdisciplinary topics are offered to students of other disciplines such as Animal Cell Biotechnology; Animal Diversity;

Aquatic Biology; Environment and Public Health; Exploring the Brain: Structure and Function; Food, Nutrition and Health; Human Physiology and Insect Vectors and Diseases.

2.2 Aim of Bachelor Degree Program

Zoology is one of the most fundamental branches of biology studied at undergraduate level. It helps to learn and understand the concepts regarding animal diversity to appreciate the variability in relation to their morphology, anatomy and behaviour among different animals. After studying this coures, our students will be more equipped to learn and know about different human systems, their coordination and control. This course will also provide an opportunity to understand theirown evolution along with other animals. They will be able to qualitatively and quantitatively analyse evolutionary parameters using various bioinformatics and computational tools used in modern sciences. This will provide them ample opportunities to explore different career avenues.

The Zoology degree program will also provide a platform to comprehend classical genetics in order to understand distribution of different traits among populations, their inheritance, ethnicity and correlate with contemporary and modern techniques like genomics, metagenomics, genome editing and molecular diagnostic tools. Practical and theoretical skills gained in this course will be helpful in designing different public health strategies for social welfare. The course has been designed to provide in-depth knowledge of applied subjects ensuring theinculcation of employment skills so that students can make a career and become an entrepreneur in diverse fields of aquatic biology, sericulture, apiculture etc. After completion of this course, students can contribute as policy makers in wild life conservation, animal preservation and environment protection.

3. Graduate Attributes in B.Sc. (Hons.) Zoology

Some of the characteristic attributes of a graduate in Zoology may include the following:

Disciplinary knowledge: Capable of demonstrating (i) comprehensive knowledge of major concepts, theoretical principles and experimental findings in Zoology and its different subfields including biodiversity, anatomy, physiology, biochemistry, biotechnology, ecology, evolutionary biology, cell biology, molecular biology, immunology and genetics, and some of the other applied areas of study such as wildlife conservation and management, apiculture, sericulture, neurosciences, aquatic biology, fish and fisheries sciences, bioinformatics and research methods; (ii) Interdisciplinary knowledge of allied biological sciences, environmental science and chemical science; (iii) learning of the various techniques, instruments, computational software used for analysis of animal's forms and functions.

Effective communicator: Capability to convey the intricate zoological information effectively and efficiently.

Critical thinker and problem solver: Ability to rationally analyze and solve the problems related to animal sciences without relying on assumptions and guess work.

Logical thinking and reasoning: Capability of seeking solutions and logically solving them by experimentation and data processing either manually or through software.

Team spirit: Ability to work effectively in a heterogeneous team.

Leadership quality: Ability to recognise and mobilise relevant resources essential for a project, and manage the project in a responsible way by following ethical scientific conduct and bio-safety protocols.

Digitally literate: Capable of using computers for biological simulation, computation and appropriate software for biostatistics, and employing search tools to locate, retrieve, and evaluate zoology-related data.

Ethical awareness: Avoiding unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, as well as appreciate environmental and sustainability issues.
Lifelong learners: Capable of self-paced and self-directed learning aimed at personal and social development.

4. Qualification Descriptors

The qualification descriptors for a Bachelors' Degree program in Zoology may include the following:
Demonstrate a logical and consistent understanding of the broad concepts in Zoology, its applications, and related interdisciplinary subjects
Technical knowledge that produces varied types of professionals in the fields like research and development, teaching, government and public sector service
Utilise wide-range knowledge, logical thinking and skills for evaluating problems and issues related to Zoology
Collection of pertinent quantitative and/or qualitative data obtained from various sources/experiments, and analysis of the data using appropriate research methodologies to formulate evidence-based solutions
Effective and precise communication of the investigations undertaken in a variety of contexts using the major concepts, principles and techniques of the subject(s)
Meet one's own learning desires, employing broad range of research and development work and professional materials
Apply one's subject knowledge and skills to novel circumstances enabling to solve complicated problems with evidence-based well-defined elucidations
Demonstrate subject-related skills relevant to Zoology-related jobs and employment opportunities

5. Program Learning Outcome

Students enrolled in B.Sc. (Hons.) degree program in Zoology will study and acquire complete knowledge of disciplinary as well as allied biological sciences. At the end of graduation, they should possess expertise which will provide them competitive advantage in pursuing higher studies from India or abroad; and seek jobs in academia, research or industries.

Students should be able to identify, classify and differentiate diverse chordates and non-chordates based on their morphological, anatomical and systemic organization. They will also be able to describe economic, ecological and medical significance of various animals in human life. This will create a curiosity and awareness among them to explore the animal diversity and take up wild life photography or wild life exploration as a career option. The procedural knowledge about identifying and classifying animals will provide students professional advantages in teaching, research and taxonomist jobs in various government organizations; including Zoological Survey of India and National Parks/Sanctuaries.

Acquired practical skills in biotechnology, biostatistics, bioinformatics and molecular biology can be used to pursue career as a scientist in drug development industry in India or abroad. Our students will be acquiring basic experimental skills in various tecniques in the fields of genetics; molecular biology; biotechnology; qualitative and quantitative microscopy; enzymology and analytical biochemistry. These methodologies will provide an extra edge to our students, who wish to undertake higher studies. In-depth knowledge and understanding about comparative anatomy and developmental biology of various biological systems; and learning about the organisation, functions, strength and weaknesses of various systems will let students critically analyse the way evolution has shaped these traits in the human body.

Students undertaking skill enhancement courses like aquaculture, sericulture and apiculture will inculcate skills involved in rearing fish, bees and silk moth which would help them in starting their own ventures and generating self employment making them successful entrepreneurs. Acquired skills in diagnostic testings, haematology, histopathology, staining procedures etc. used in clinical and research laboratories will provide them opportunity to work in diagnostic or research laboratory. Deep understanding of different physiological systems and methods available to measure vital physiological parameters and to comprehend the mechanism behind occurrence of different life threatening disease *via* laboratory examination, assessment of basic physiological functions by interpreting physiological charts will help to find their career options.

Students undertaking wild life management courses would gain expertise in identifying key factors of wild life management and be aware about different techniques of estimating, remote sensing and Global positioning of wild life. This course will motivate students to pursue a career in the field of wildlife conservation and management.

6. Course Structure

6.1 Credit distribution for the course

Semester	Course Opted	Course Name	Credits
I	Ability Enhancement Compulsory Course-I	English/Hindi/MIL Communication/ Environmental Science	4
	Core Course-I	Non-chordates I: Protista to Pseudocoelomates	4
	Core Course-I Practical		2
	Core Course-II	Principles of Ecology	4
	Core Course-II Practical		2
	Generic Elective -1	GE-1	4
	Generic Elective -1 Practical/Tutorial		2
II	Ability Enhancement Compulsory Course-II	English/Hindi/MIL Communication/ Environmental Science	4
	Core Course-III	Non-chordates II: Coelomates	4
	Core Course-III Practical		2
	Core course-IV	Cell Biology	4
	Core Course-IV Practical		2
	Generic Elective -2	GE-2	4
	Generic Elective -2 Practical		2
III	Core Course-V	Diversity of Chordates	4
	Core Course-V Practical		2
	Core Course-VI	Physiology: Controlling and Coordinating system	4
	Core Course-VI Practical		2
	Core Course-VII	Fundamentals of Biochemistry	4
	Core Course-VII Practical		2
	Skill Enhancement Course-1	SEC-1	4
	Generic Elective -3	GE-3	4
	Generic Elective -3 Practical		2

Semester	Course Opted	Course Name	Credits
IV	Core Course-VIII	Comparative Anatomy of Vertebrates	4
	Course-VIII Practical		2
	Core Course-IX	Physiology: Life Sustaining Systems	4
	Course-IX Practical		2
	Core Course-X	Biochemistry of Metabolic Processes	4
	Core Course- X Practical		2
	Skill Enhancement Course-2	SEC-2	4
	Generic Elective -4	GE-4	4
	Generic Elective -4 Practical		2
V	Core Course-XI	Molecular Biology	4
	Core Course-XI Practical		2
	Core course-XII	Principles of Genetics	4
	Core Course-XII Practical		2
	Discipline Specific Elective -1	DSE-1	4
	Discipline Specific Elective -1 Practical		2
	Discipline Specific Elective -2	DSE-2	4
	Discipline Specific Elective- 2 Practical		2
VI	Core Course-XIII	Developmental Biology	4
	Core Course-XIII Practical		2
	Core course-XIV	Evolutionary biology	4
	Core Course-XIV Practical		2
	Discipline Centric Elective -3	DSE-3	4
	Discipline Centric Elective -3 Practical		2
	Discipline Centric Elective-4	DSE-4	4
	Discipline Centric Elective -1 Practical		2
			Total:148

6.2 Semester-wise Distribution of Courses

Sem	Core Course(14)	Ability Enhancement Compulsory Course AECC (2)	Skill Enhancement Course SEC (2)	Discipline SpecificElective DSE (4)	Generic Elective GE (4)
I	Non-chordates I: Protista to Pseudocoelomates	English/Hindi/MIL Communication/Environmental Science			GE-1
	Principles of Ecology				
II	Non-chordates II: Coelomates	English/Hindi/MIL Communication/Environmental Science			GE-2
	Cell Biology				
III	Diversity of Chordates		SEC -1		GE-3
	Physiology: Controlling and Coordinating Systems				
	Fundamentals of Biochemistry				
IV	Comparative Anatomy of Vertebrates		SEC -2		GE-4
	Physiology: Life Sustaining Systems				
	Biochemistry of Metabolic Processes				
V	Molecular Biology			DSE-1	
	Principles of Genetics			DSE-2	
VI	Developmental Biology			DSE -3	,
	Evolutionary Biology			DSE-4	

Discipline Specific Electives (DSE)

- Animal Behaviour
- Basics of Neuroscience
- Biotechnology
- Biology of Insecta
- Reproductive Biology
- Wildlife Management
- Computational Biology
- Parasitology
- Immunology
- Endocrinology
- Fish and Fishries

Skill Enhancement Courses (SEC)

- Medical Diagnostics
- Research Methodology
- Apiculture
- Sericulture
- Aquarium Fish Keeping
- Genetic counselling
- Environmental Audit

Generic Electives (GE)

- Human Physiology
- Animal Diversity
- Environment & Public Health
- Insect Vector & Diseases
- Animal Cell Biotechnology
- Food, Nutrition & Health
- Aquatic Biology
- Exploring the Brain: Structure and Function

7. Courses for B.Sc. (Hons.) Zoology

ZH Core-I: Non-Chordates I: Protists to Pseudocoelomates

Course Learning Objective:

The coursewould provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life. It will help the student to understand the features of Kingdom Animalia and systematic organisation of the animals based on their evolutionary relationships, structural and functional affinities. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Learn about the importance of systematics, taxonomy and structural organization of animals.
- Appreciate the diversity of non-chordates living in varied habit and habitats.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- Critically analyse the organization, complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representatives of various animal phyla.
- Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Course Content:

Theory [Credits: 4] 60hrs

<u>Unit 1:</u> Introduction to Animalia 3 hrs
General Characteristics of Kingdom Animalia and Basis of Classification
(Chapter 1, 4, 6 and 9: Barnes, R.D.; Chapter 2: Pechenik, J. A.)

<u>Unit 2:</u> Protista 17 hrs
General characteristics and Classification up to classes; Study of *Euglena* and *Paramecium.* Life cycle and pathogenicity of *Plasmodium vivax;* Locomotion and Reproduction in Protista
(Chapter 3: Barnes, R.D.; Chapter 3: Pechenik, J. A.)

<u>Unit 3:</u> Porifera 7 hrs
Introduction to Parazoa; General characteristics and Classification up to classes; Study of *Sycon;* Canal system in sponges
(Chapter 5: Barnes, R.D.; Chapter 4: Pechenik, J. A.
Flagellar apparatus structure of choanocyte in Sycon sp. and its significance for phylogeny of Porifera.Pozdnyakov, I.R. & Karpov, S.A. Zoomorphology (2013) 132: 351)

<u>Unit 4:</u> Cnidaria 12 hrs
Introduction to Metazoa: General characteristics and Classification up to classes; Metagenesis in *Obelia;* Polymorphism in Cnidaria; Corals and coral reefs
(Chapter 6, 7 and 9: Barnes, R.D.; Chapter 6: Pechenik, J. A.)

Unit 5: Ctenophora 3 hrs
General characteristics and evolutionary significance
(Chapter 8: Barnes, R.D.; Chapter 7: Pechenik, J. A.)

Unit 6: Platyhelminthes 10 hrs
General characteristics and Classification up to classes; Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium;* Parasitic adaptations in Platyhelminthes
(Chapter 10: Barnes, R.D.; Chapter 8: Pechenik, J. A.)

Unit 7: Nemathelminthes 7 hrs
General characteristics and Classification up to classes; Life cycle, and pathogenicity of *Ascaris lumbricoides;* Parasitic adaptations in Nemathelminthes
(Chapter 11: Barnes, R.D.; Chapter 16: Pechenik, J. A.)

Practical[Credits 2]

1. Study of whole mount of *Euglena*, *Amoeba, Noctiluca, Paramecium,* Binary fission in *Paramecium* and Conjugation in *Paramecium*
2. Examination of pond water collected from different places to observe diversity in Protista
3. Study of *Sycon, Hyalonema, Euplectella, Spongilla,* T.S. of *Sycon,* L.S. of *Sycon*
4. Study of *Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium/Adamsia, Pennatula, Fungia, Meandrina, Madrepora,* T.S. of *Metridium/Adamsia*
5. One specimen/slide of any Ctenophore
6. Study of adult *Fasciola hepatica*, *Taenia solium* and their life stages (Slides/micro-photographs)
7. Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs)
8. To submit a Project Report on any related topic on life cycle of any one parasite or pathogen/corals/coral reefs.
9. Examination of soil samples collected from different places to observe diversity in nematodes

Note: Classification to be followed from "Barnes, R.D. (2006). *Invertebrate Zoology*, VII Edition, Cengage Learning, India"

Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and round tables on the various aspects of non-chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behaviour of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non-chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students.

Assessment Methods:

Various measures adopted will be as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones during which students will be evaluated.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce***: *Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Keywords:

Acoelomates, Classification, Cnidaria, Ctenophora, Diploblastic, Helminths, Metazoa, Parazoa, Porifera, Protista, Protostomia, Pseudocoelomates, Structural organization, Symmetry, Triploblastic

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education

  *Note: Classification to be followed from "Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India"

Suggested Readings:

- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis. III Edition, Blackwell Science
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Online Tools and Web Resources:

- Swayam (MHRD) Portal
- Animal Diversity (https://swayam.gov.in/courses/5686-animal-diversity)
- Advances in Animal Diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology)
- ePG Pathshala (MHRD)Module 10, 18, 19 of the paper P-08 (Biology of Parasitism) https://epgp.inflibnet.ac.in/ahl.php?csrno=35

ZH Core-II: Principles of Ecology

Course Learning Objective:

The primary aim of the syllabus is to sensitize the students about the paramount role and importance of nature. The study of Ecology imparts us the knowledge about the judicious use of existing ecological resources for sustainable development. Ecology is the only branch of science which briefs us on the ways and means of living with nature for mutual benefit. Study of ecology will provide students opportunity to understand its practical aspects and helps them to solve many contemporary ecological issues such as global warming, land degradation, habitat loss, desertification and pollution etc. The hands-on experiences of laboratory will also enable students to understand the ecosystem and ecology in a better way.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Demonstrate an understanding of key concepts in ecology with emphasis on historical perspective, role of physical factors and concept of limiting factors.
- Comprehend the population characteristics, dynamics, growth models and interactions.
- Understand the community characteristics, ecosystem development and climax theories.
- Know about the types of ecosystems, food chains, food webs, energy models, and ecological efficiencies.
- Apply the basic principles of ecology in wildlife conservation and management.
- Inculcate scientific quantitative skills, evaluate experimental design, read graphs, and analyse and use information available in scientific literature.

Course Content:

Theory [Credits: 4] 60 hrs

<u>Unit1</u>: Introduction to Ecology 5 hrs

History and Scope of ecology, Autecology and synecology, Laws of limiting factors, Study of physical factors: Temperature and Light

(Chapter 1: Smith, R. L.; Chapter 1 and 5: Odum, E.P.; Chapter 1 and 5: Odum, E. P. and G. W. Barrette)

<u>Unit 2</u>: Population 24 hrs

Unitary and Modular populations; Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion; Exponential and logistic growth, equation and patterns, *r* and *k* strategies, Population regulation; Density-dependent and independent factors; Population interactions; Gause’s Principle with laboratory and field examples; Lotka-Volterra equation for competition and predation; Functional and numerical responses

(Chapter 17, 18, 19, 20, 22 and 23: Smith, R. L.; Chapter 6 and 7: Odum, E. P. and G. W. Barrette)

<u>Unit 3</u>: Community 12 hrs

Community characteristics: species richness, dominance, diversity, abundance, Guilds, Ecotone and edge effect; Ecological succession with examples and types; Theories pertaining to climax community.

(Chapter 28 and 30: Smith, R. L.; Chapter 7: Odum, E. P. and G. W. Barrette)

<u>Unit 4</u>: Ecosystem 14 hrs

Types of ecosystems with detailed study of any one: Forest Ecosystem, Pond or Lake ecosystem, Mangrove and Coral reef ecosystem. Vertical stratification in Forest and Aquatic ecosystem, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies, Nutrient and biogeochemical cycle with one example of Nitrogen cycle
(Chapter 10, 11 and 12: Smith, R. L.; Chapter 2 and 4: Odum, E. P. and G. W. Barrette)

<u>Unit 5</u>: Applied Ecology 5 hrs

Ecology in wildlife conservation and management, Biodiversity types, Importance & threats, Protected areas: National Parks, Bioreserves and Sanctuaries, Restoration ecology, Global climate change and its mitigation
(Chapters 1 and 3: Saha and Mazumdar)

Practical [Credits: 2]

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community
3. Study of an aquatic ecosystem: phytoplankton and zooplankton, measurement of area, temperature, turbidity/penetration of light, determination of pH, and dissolved oxygen content (Winkler's method), chemical oxygen demand and free CO_2, alkalinity
4. Report on a visit to National Park/Biodiversity Park/Wildlife sanctuary

Teaching and Learning Process:

The course involves four hours each of classroom teaching and laboratory activity per week. Classroom work would include lectures based on textbook and scientific journal readings. Lectures will consist of traditional board teaching as well as power point presentations. Learning process will also include participatory activities like focused group discussions, presentations by students, experience sharing, brainstorming and project writing. Field trip activities to National parks and Eco-parks would complement and enhance understanding of the course concepts and information about the wildlife and its conservation. Laboratory work will provide students the first hands-on experience for better understanding of the subject.

Assessment Methods:

- Evaluation will determine the extent to which the students demonstrate desired learning outcomes.
- Multiple assessment methods will be used as evaluation criteria which include continuous assessment, assignments, tests, class presentations and mock tests.
- Project writing based on leanings from field trips will also be held for comparative evaluation of students.

Keywords:

Ecology, Community ecology, Population ecology, Biodiversity, Wildlife, Food Chain, Food web, Food pyramids

Recommended Books:

- Odum, E.P. (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
- Smith, R. L. (2000). Ecology and field biology. Harper and Row publisher

Suggested Readings:

- Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
- Ricklefs, R.E. (2000). Ecology. V Edition. Chiron Press.

ZH Core-III: Non-Chordates II: Coelomates

Course Learning Objective:
The coursewould provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life. It will help the student to understand the features of Kingdom Animalia and systematic organisation of the animals based on their evolutionary relationships, structural and functional affinities. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

Course Learning Outcome:
Upon completion of the course, students should be able to:

- Learn about the importance of systematics, taxonomy and structural organization of animals.
- Appreciate the diversity of non-chordates living in diverse habit and habitats.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- Critically think about the organization, complexity and characteristic features of non-chordates.
- Getting familiarized with the morphology and anatomy of representatives of various animal phyla.
- Comprehendthe economic importance of non-chordates, their interaction with the environment and role in the ecosystem.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Course Content:
Theory [Credits: 4] 60 hrs

Unit 1: Introduction to Coelomates 2 hrs
Evolution of coelom and metamerism
(Chapter 9 and 27: Barnes, R.D.; Chapter 5: Pechenik, J. A.)

Unit 2: Annelida 14 hrs
General characteristics and Classification up to classes; Digestion, Excretion and Reproduction in Annelida
(Chapter 13: Barnes, R.D.; Chapter 13: Pechenik, J. A.)

Unit 3: Arthropoda 17 hrs
General characteristics and Classification up to classes, Classification of Insecta up to orders
Vision and Respiration in Arthropoda; Metamorphosis in Insects; Social life in bees and termites
(Chapters 16-21: Barnes, R.D.; Chapter 14: Pechenik, J. A.)

Unit 4:Onychophora 2 hrs
General characteristics and Evolutionary significance
(Chapter 15: Barnes, R.D.; Chapter 15: Pechenik, J. A.)

<u>Unit 5</u>: Mollusca 14 hrs

General characteristics and Classification up to classes; Respiration in Mollusca; Torsion and detorsion in Gastropoda; Pearl formation in bivalves

(Chapter 12: Barnes, R.D.; Chapter 12: Pechenik, J. A.)

<u>Unit 6:</u> Echinodermata 11 hrs

General characteristics and Classification up to classes; Protective mechanisms in echinoderms (Dermal skeleton, evisceration, autotomy); Water-vascular system in Asteroidea; Larval forms in echinoderms

(Chapter 28: Barnes, R.D.; Chapter 20: Pechenik, J. A.)

Practical [Credits: 2]

1. Study of *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria,* Trochophore larva
2. Study of T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm
3. Study of *Limulus*, *Palamnaeus, Palaemon, Daphnia*, *Balanus*, *Sacculina*, *Cancer*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx*, *Periplaneta,* termites, *Apis, Musca,* Crustacean larvae (Any three)
4. Study of *Peripatus*
5. Study of *Chiton, Dentalium, Pila, Doris, Helix, Unio, Patella,Ostrea, Pinctada, Sepia, Octopus, Nautilus*
6. Study of *Pentaceros/Asterias, Ophiura, Clypeaster, Echinus, Cucumaria, Antedon*
7. Study of mouth parts, digestive system and nervous system of *Periplaneta**
8. Submit a Project Report on field study of the social behaviour of any insect (bees/termites/ants/wasps) or behavioural pattern of earthworm in nature.
   (*Subject to UGC guidelines)

Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted not only through classroom lectures to inculcate a conceptual base among the students about the subject but also through observations in nature and through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of non-chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behaviour of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non-chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills; and enhance the critical thinking of the students.

Assessment Methods:

Various measures adopted will be as follows:

- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones during which students will be evaluated.
- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcome will be held.
- Regular Presentations: Presentations by the students on a particular topic will enhance students' learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- *Viva-voce: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

Keywords:

Annelida, Arthropoda, Coelomates, Classification, Deuterostomia, Echinodermata, Insecta, Metamerism, Metazoa, Mollusca, Onychophora, Structural organization, Symmetry, Triploblastic

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education

  *Note: Classification to be followed from "Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India"

Suggested Readings:

- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Online Tools and Web Resources:

- Swayam (MHRD) Portal
- Animal Diversity (https://swayam.gov.in/courses/5686-animal-diversity)
- Advances in Animal Diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology)

ZH Core IV: Cell Biology

Course Learning Objective:

The objective of the course is to help the students to learn and develop an understanding of a cell as a basic unit of life. This course is designed to enable them to understand the functions of cellular organelles and how a cell carries out and regulates cellular functions.

Course Learning Outcome:

Upon completion of the course, students should to be able to:

- Understand fundamental principles of cell biology.
- Explain structure and functions of cell organelles involved in diverse cellular processes.
- Appreciate how cells grow, divide, survive, die and regulate these important processes.
- Comprehend the process of cell signalling and its role in cellular functions.
- Have an insight of how defects in functioning of cell organelles and regulation of cellular processes can develop into diseases.
- Learn the advances made in the field of cell biology and their applications.

Course Content:
Theory [Credits: 4] 60 hrs

Unit 1: Overview of Cells 3 hrs

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions
(Chapter 1: Cooper; Chapter 4: Becker; Chapter 1: Karp)

Unit 2: Plasma Membrane 7 hrs

Various models of plasma membrane structures, Transport across membranes: active and passive transport, facilitated transport; Cell-cell junctions, structures and functions: Tight junctions, adherens junctions, gap junctions
(Chapter 13: Cooper; Chapter 7: Becker; Chapter 4; Karp)

Unit 3: Endomembrane System 12 hrs

Structure and Functions: Endoplasmic Reticulum, Signal hypothesis, Vesicular transport from ER to Golgi apparatus; Protein sorting and transport from Golgi apparatus; Golgi apparatus, Vesicular transport: Coated Vesicles; Lysosomes; Peroxisomes.
(Chapter 10, 11: Cooper; Chapter 12: Becker; Chapter 8: Karp)

Unit 4: Mitochondria 8 hrs

Structure, Semi-autonomous nature, Endo-symbiotic hypothesis; Respiratory chain, Chemi-osmotic hypothesis and ATP Synthase.
(Chapter 11: Cooper; Chapter 10: Becker; Chapter 5)

Unit 5: Cytoskeleton 7 hrs

Structure and Functions: Microtubules, Microfilaments and Intermediate filaments.
(Chapter 12: Cooper; Chapter 15: Becker; Chapter 9: Karp)

Unit 6: Nucleus 8 hrs

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Transport of molecules across nuclear membrane, Chromatin: euchromatin, heterochromatin and packaging, nucleosome, nucleolus

(Chapter 9: Cooper; Chapter 18: Becker)

<u>Unit 7</u>: Cell Division 8 hrs
Mitosis, Meiosis, Cell cycle and its regulation
(Chapter 16: Cooper; Chapter 14: Karp)

<u>Unit 8</u>: Cell Signalling 7 hrs
Cell Signalling through G-protein coupled receptor (GPCR) and role of secondary messenger: cAMP and protein kinase; Apoptosis.
(Chapter 15: Cooper; Chapter 14: Becker; Chapter 15: Karp)

Practical [Credit: 2]

1. Principle of Light microscope, Phase contrast microscope and Electron microscope and principle of cell fixation, staining and fractionation.
2. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
3. Study the effect of colchicine on mitosis at 24 hrs and 48 hrs.
4. Study of various stages of meiosis.
5. Preparation of temporary stained mount to show the presence of Barr body in human female blood cells/ cheek cells.
6. Cytochemical staining and preparation of permanent slide to demonstrate:
    (a) DNA by Feulgen reaction
    (b) Mucopolysaccharides by PAS reaction
    (c) Proteins by Mercuric Bromophenol Blue/Acid Fast Green.

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.
- A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questions on start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

The assessment of students' achievement in Cell Biology will be aligned with the course learning outcomes.

- Continuous evaluation of learning by diagnostic and formative methods.
- Project work, quiz, problem solving exercise, classroom assessment methods, closed-book and open-book tests, problem-solving exercises, practical assignment, laboratory reports, seminar presentation, *viva voce* interviews, computerized adaptive testing, literature surveys and summative evaluations by end-semester examination etc. will constitute the different components of the overall assessment.

Keywords:

Cell organelles, cell membrane, cell junctions, endomembrane system, cytoskeleton, mitosis, meiosis, cell signaling

Recommended Books:

- Cooper, G.M., Hausman, R.E. (2009) The Cell: A Molecular Approach. V Edition, ASM Press and Sinauer Associates.
- Becker, Kleinsmith, and Hardin (2009) The World of the Cell,VIII Edition, Benjamin Cummings Publishing, San Francisco.
- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments,VI Edition, John Wiley & Sons Inc.

Suggested Readings:

- De Robertis, E.D.P. and De Robertis, E.M.F. (2009) The Cell and Molecular Biology, Lippincott Williams & Wilkins, Philadelphia.
- Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Robert Keith and Watson James. (2008). Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.

Online Tools and Web Resources:

- https://swayam.gov.in/course/150-cell-biology
- https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology
- https://www.jove.com/science-education-library/9/cell-biology
- https://www.khanacademy.org/science/biology

ZH Core V: Diversity of Chordates

Course Learning Objective:

The course is designed with an aim to provide scope and historical background of chordates. It will impart knowledge regarding basic concepts of origin of chordates and make the students understand the characteristics and classification of animals with notochord. The exclusive phenomena in chordates like biting mechanism in snakes, flight adaptations in birds etc. will be explained. The adequate explanation to the students regarding various mechanisms involved in thriving survival of the animals within their geographic realms will create interest among students.

Course Learning Outcome:

Upon completion of the course, the students will be able to:

- Understand different classes of chordates, level of organization and evolutionary relationship between different subphyla and classes, within and outside the phylum.
- Study about diversity in animals making students understand about their distinguishing features.
- Appreciate similarities and differences in life functions among various groups of animals in Phylum Chordata.
- Comprehend the circulatory, nervous and skeletal system of chordates.
- Know about the habit and habitat of chordates in marine, freshwater and terrestrial ecosystems.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Introduction to Chordates 2 hrs

General characteristics and outline classification

(Chapter 2: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 2: Protochordata 9 hrs

General characteristics of Hemichordata, Urochordata and Cephalochordata; Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata

(Chapter 3: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 3: Origin of Chordata 3 hrs

Dipleurula concept and the Echinoderm theory of origin of chordates,

(Chapter 3: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 4: Agnatha 2 hrs

General characteristics and classification of cyclostomes up to Class

(Chapter 4: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 5: Pisces 9 hrs

General characteristics of Chondrichthyes and Osteichthyes, Classification up to order Migration, Osmoregulation and Swim bladder in Fish

(Chapter 6, 7, 8, 9 and 10: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 6: Amphibia 6 hrs
Origin of Tetrapoda (Evolution of terrestrial ectotherms); General characteristics and classification up to order; Parental care in Amphibians
(Chapter 11 and 12: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 7: Reptilia 7 hrs
General characteristics and classification up to order; Affinities of *Sphenodon*; Poison apparatus and biting mechanism in snakes
(Chapter 13 and 14: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 8: Aves 8 hrs
General characteristics and classification up to order; *Archaeopteryx*- a connecting link; Flight adaptations and migration in birds
(Chapter 15, 16 and 17: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 9: Mammals 7 hrs
General characters and classification up to order; Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages
(Chapter 18-31: Young, J. Z.; Parker T.J. and Haswell W.A.)

Unit 10: Zoogeography 7 hrs
Zoogeographical realms, Plate tectonic and Continental drift theory, Distribution of vertebrates in different realms
(Chapter 1: Young, J. Z.; Chapter 1, 7, 8 & 9: Darlington P.J.)

Practical [Credits: 2]
1. Protochordata: *Balanoglossus, Herdmania, Branchiostoma*, Colonial Urochordata, Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slide of *Herdmania* spicules
2. Agnatha: Petromyzon, Myxine
3. Fish: Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetrodon/ Diodon, Anabas, Flat fish
4. Amphibia: Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandra
5. Reptilia: Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus; Key for Identification of poisonous and non-poisonous snakes
6. Aves: Study of six common birds from different orders. Types of beaks and claws
7. Mammalia: *Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus, Loris, Herpestes, Erinaceous.*
8. Study of Weberian ossicles of *Mystus*, pecten from fowl head and brain of fowl
9. Power point presentation on study of any two animals from two different classes by students

Teaching and Learning Process:
- Animal pictures and models
- Related videos
- Powerpoint presentations
- Maximizing interaction with students
- Mentoring
- Analysis of scientific articles

Assessment Methods:
- Assignments
- Class test
- *Viva-voce*
- MCQs
- Paper presentations
- Continuous assessment

Keywords:
Chordata, Origin, General characteristics, Classification, Protochordata, Agnatha, Cyclostomes, Pisces, Tetrapoda, Amphibia, Reptiles, Aves, Mammals, Zoogeography

Recommended Books:
- Young, J. Z. (2004). The Life of Vertebrates. III Edition, Oxford university press.
- Parker T.J. and Haswell W.A. (1972). Textbook of Zoology Vertebrates.VII Edition, Volume II
- Pough H. (2018). Vertebrate life X Edition, Pearson International.

Suggested Readings:
- Darlington P.J. (1966). The Geographical Distribution of Animals, R.E. Krieger Pub. Co.
- Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.

Online Tools and Web Resources:
- https://www.khanacademy.org/science/biology/crash-course-bio-ecology/crash-course-biology-science/v/crash-course-biology-123
- https://opentextbc.ca/biology2eopenstax/chapter/chordates/

ZH Core -VI: Physiology: Controlling and Coordinating Systems

Course Learning Objective:

Physiology is the study of life, specifically, how cells, tissues and organ function. It is a core and fundamental scientific discipline that underpins the health and well-being of living organisms. Besides satisfying a natural curiosity about how our body systems function, it gives us knowledge about the functions of all the parts and systems of the body. It is also of central importance in medicine and related health sciences. The course has been designed to extend the fundamental or coherent understanding of the subject to related disciplinary areas/subjectsthrough understanding of normal body functions, assisting in more effective treatment of abnormal or diseased states. It will equip the students with skill-based knowledge, enabling them to undertake further studies in physiology and related areas as well as in multidisciplinary subjects.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Know the basic fundamentals and understand advanced concepts so as to develop a strong foundation that will help them to acquire skills and knowledge to pursue advanced degree courses.
- Comprehend and analyze problem-based questions
- Recognize and explain how all physiological systems work in unison to maintain homeostasis in the body and use of feedback loops to control the same
- Learn an integrative approach to understand the interactions of various organ systems resulting in the complex overall functioning of the body. Synthesize ideas to make connection between knowledge of physiology and real world situations, including healthy life style decisions and homeostatic imbalances
- Know the role of regulatory systems *viz.* endocrine and nervous systems and their amalgamation in maintaining various physiological processes.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Tissues 6 hrs

Structure, location, classification and functions of Epithelial tissue, Connective tissue, Muscular tissue and Nervous tissue

(Chapter 4: Tortora, G.J & Grabowski, S)

Unit2: Bone and Cartilage 4hrs

Histology of different types of bones and cartilages

(*Chapter 6: Tortora, G.J & Grabowski, S)*

Unit 3: Nervous System 12 hrs

Structure of neuron, Resting membrane potential, Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; Types of synapse, Synaptic transmission, Neuromuscular junction; Physiology of hearing and vision.

(*Chapter 12: Tortora, G.J & Grabowski, S)*

Unit 4: Muscle 12 hrs

Histology of different types of muscle; Ultrastructure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, Summation and tetanus
(*Chapter 10: Tortora, G.J & Grabowski, S)*

<u>Unit 5</u>: Reproductive System 8 hrs
Histology of testis and ovary; Physiology of male and female reproduction
(*Chapter 28: Tortora, G.J & Grabowski, S)*

<u>Unit 6</u>: Endocrine System 18 hrs
Histology of endocrine glands- pineal, pituitary, thyroid, parathyroid, pancreas, adrenal; Hormones secreted by them and their physiological action; Classification of hormones; Regulation of their secretion; Mode of hormone action- Signal transduction pathways for steroidal and non-steroidal hormones
(*Chapter 18: Tortora, G.J & Grabowski, S)*

Practical [Credits: 2]

1. * Recording of simple muscle twitch with electrical stimulation (or Virtual)
2. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)
3. Preparation of temporary mounts: Squamous epithelium, Striated muscle fibres, Nerve cells
4. Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid
5. Demonstration of technique of microtomy to have hands-on experience and learning of the technique.
6. Submission of a Project report on methods of contraception in male and female.

(*Subject to UGC guidelines)

Teaching and Learning Process:

The Learning Outcomes-Based Approach to curriculum planning and execution requires that the teaching learning processes are oriented towards enabling students to attain the defined learning outcomes relating to the courses within a programme. This, particularly in the context of undergraduate studies, requires a significant shift from teacher centric to learner/ student centric, pedagogies and from passive to active/participatory pedagogies. Practical skills, including an appreciation of the link between theory and experiment will constitute an important aspect of the teaching-learning process.

Teaching methods will include:

- Lectures supported by group tutorial work; invited lectures
- Practical and field-based learning;
- Use of prescribed textbooks and e-learning resources and other self-study materials;
- Project work
- Assignments, seminars, oral presentations
- Activities designed to promote the development of generic/transferable and subject specific skills;
- Internships and visits to field sites and hospitals or other research facilities
- Guidance by the mentors and specialists in the field etc.

Assessment Methods:

A variety of assessment methods will be used to assess progress towards the course learning outcomes. Priority will be accorded to formative assessment. Progress towards achievements of learning outcomes will be assessed using the following:

- Theory and practical examinations;
- Problem based assignments;
- Practical assignment, laboratory exercises and reports; observation of practical skills;
- Individual project reports (case-study reports); team project reports;
- Oral presentations, including seminar presentations; viva voce interviews;
- Peer and self-assessment, literature survey evaluations etc.

Keywords:

Epithelial and connective tissues, Bones, Cartilage, Neuron, Membrane potential, Graded potential, Synapse, Neuromuscular junction, Neurotransmitter, Skeletal muscle, Sarcomere, Testes, Ovary, Endocrine glands, Hormones, Negative feedback mechanism, Signal transduction pathway.

RecommendedBooks:

- Tortora, G.J. and Grabowski, S. (2006). Principles of Anatomy & Physiology. XI edition.John Wiley & Sons
- Vander, A., Sherman, J., and Luciano, D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, Mc Graw Hills

Suggested Readings:

- Ganong, W.F. (2019) Review of Medical Physiology. 26th Edition, Mc Graw-Hill
- Guyton, A.C. & Hall, J.E. (2006).Textbook of Medical Physiology. XI Edition.Hercourt Asia PTE Ltd/W.B. Saunders Company
- Marieb, E.N. (1998) Human Anatomy and Physiology. IV Edition, Addison Wesley Longman Inc.

Online Tools and Web Resources:

- e portals like SWAYAM and
- http://nsdl.niscair.res.in

ZH Core-VII: Fundamentals of Biochemistry

Course Learning Objective:

Biochemistry is to understand the core biological phenomena at the molecular level. The aim of the course is to comprehend the fundamental principles of chemistry that govern complex biological systems.The program is designed to enable a student acquire sound knowledge of biochemistry and its practicable applicability. To make the study relevant, interesting, encouraging to the students to join the industry or to prepare them for higher studies including research. The new and updated syllabus is based on a basic and applied approach to ensure that students develop problem solving skills, laboratory skills, chemistry communication skills, team skills as well as ethics.

Course Learning Outcome:

- Upon completion of the course, students should be able to: Gain knowledge and skill in the fundamentals of biochemical sciences, interactions and interdependence of physiological and biochemical processes.
- Get exposed to various processes used in industries and gain skills in techniques of chromatography and spectroscopy.
- Demonstrate foundation knowledge in biochemistry; synthesis of proteins, lipids, nucleic acids, and carbohydrates; and their role in metabolic pathways along with their regulation.
- Know about classical laboratory techniques, use modern instrumentation, design and conduct scientific experiments, and analyze the resulting data.
- Be knowledgeable in proper procedures and regulations in handling and disposal of chemicals.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Carbohydrates 8 hrs

Structure and Biological importance: with emphasis on aldose, ketose, chiral centre, polarised light and Fischer nomenclature, Cyclization reaction of glucose, anomers, pyranose, furanose, glycosidic linkage;Reducing and non-reducing sugars: monosaccharides, disaccharides, polysaccharides and Glycoconjugates

(Chapter 7: Cox, M.M and Nelson, D.L.; Chapter 11: Berg, J.M., Tymoczko, J.L. and Stryer, L.).

Unit 2: Lipids 8hrs

Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids

(Chapter 10: Cox, M.M and Nelson, D.L.; Chapter 12: Berg, J.M., Tymoczko, J.L. and Stryer, L.).

Unit 3: Proteins 14 hrs

Amino acids: Structure, Classification and General properties of α-aminoacids; Physiological importance of essential and non-essential α-amino acids; Proteins: Bonds stabilizing protein structure; Levels of organization in proteinmotifs, folds anddomains; Denaturation; Introduction to simple and conjugate proteins. Immunoglobulins: Basic Structure,

(Chapter 4 and 5: Cox, M.M and Nelson, D.L.; Chapter 3: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

<u>Unit 4</u>: Nucleic Acids 12hrs

Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids; Cot Curves: Base pairing, Denaturation and Renaturation of DNA; Types of DNA and RNA, Complementarity of DNA, Hypo-Hyperchromicity of DNA

(Chapter 8: Cox, M.M and Nelson, D.L.; Chapter 5: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

<u>Unit 5</u>: Enzymes 18 hrs

Nomenclature and classification; Cofactors; Specificity of enzyme action;Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affectingrate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation,Concept of Km and Vmax, Lineweaver-Burk plot; Multi-substrate reactions;Enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme reaction

(Chapter 6: Cox, M.M and Nelson, D.L.; Chapter 8: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Practical [Credits: 2]

1. To understand the preparation and roles of two important biological buffer systems: phosphate and bicarbonate; Preparation of buffers and determination of pH
2. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
3. Quantitative Tests: Determination of Ascorbic acid – DCPIP method OR Estimation of Calcium–Titrimetric method.
4. Paper chromatography of amino acids.
5. Action of salivary amylase under optimum conditions.
6. Effect of pH, temperature and inhibitors on the action of salivary amylase.
7. Demonstration of proteins separation by SDS-PAGE.

Teaching and Learning Process:

At the end of the IV Semester, the UG student is expected to demonstrate clear understanding of general concepts and fundamental biochemical principles; such as structure/function of biomolecules metabolic pathways, regulation of biological and biochemical processes through class room lectures and encourage interactive learning with simulation studies including animations, presentations. Principles of various biochemical techniques will be explained through advanced instrumentations. The data will be analysed and interpreted with computer-assisted software.Project-based studies will help students devise experiments independently.

Assessment Methods:

- Continuous Assessment by regular class tests; Projects and Assignments both individual/group projects to inculcate independent thinking as well as team work among the students. Regular Presentationsto be assessed based on the content, novelty, explanation and response to queries.
- Online Assignment/Project Submission; Self-assessment through Quiz.
- Concept maps (Diagram with hierarchical nodes, labeled with concepts), Concept (The instructor presents one or more questions during class along with several possible answers), Oral/Poster Presentation.

- Use of free video recording tool and online video platform (such as PresentationTube; http://presentationtube.com/). It helps to connect and train teachers and students to record, publish, and share quality video tutorials.

Keywords:

Carbohydrates, Lipids, Proteins, Enzymes, Amino acids, Nucleic acids, DNA, RNA, Conjugates, Steroids

Recommended Books:

- Cox, M.M and Nelson, D.L. (2008).Lehninger's Principles of Biochemistry. VEdition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry. VI Edition,W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. andWell, P.A. (2009). Harper's Illustrated Biochemistry. XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.

Suggested Reading:

- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry. II Edition, BIOS Scientific Publishers Ltd., U.K.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene. VI Edition, Cold Spring Harbor Lab.Press, Pearson Pub.

Online Tools and Web Resources:

- CECGurukul (www.cec.nic.in)
- https://www.youtube.com/user/cecedusat/featured.
- National Institute of Science Communication and Information Resources (NISCAIR) (http://www.niscair.res.in/) and National Science Digital Library (NSDL) (www.nsdl.niscair.res.in).
- National Digital Library of India (NDL India; https://ndl.iitkgp.ac.in/).

ZH Core-VIII: Comparative Anatomy of Vertebrates

Course Learning Objective:

This course aims to provide the undergraduate students a thorough knowledge of structural details and comparative account of the different organ systems of the body from lower to higher vertebrates, and protochordates, thus enabling them to appreciate the incredible vertebrate diversity. The course furnishes an understanding of evolutionary basis of morphological and anatomical differences as well as similarities that occur among vertebrates. It helps students propose possible homology between structures, and understand how they evolved as the vertebrates dwelled different habitats. The structural modifications of digestive, circulatory, respiratory and skeletal system relates to the distribution of animals in their different comfort zones of habitat and ecological niches. The understanding of anatomical details of organ systems of mammals like rat and mice aims to gives the basic information for their use in experimental and research studies in different branches of Zoology like Immunology, Medical Zoology and Reproductive Biology etc.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Explain comparative account of the different vertebrate systems
- Understand the pattern of vertebrate evolution, organisation and functions of various systems.
- Learn the comparative account of integument, skeletal components, their functions and modifications in different vertebrates.
- Understand the evolution of heart, modification in aortic arches, structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates; and digestive system and its anatomical specializations with respect to different diets and feeding habits.
- Learn the evolution of brain, sense organs and excretory organsto a complex, highly evolved form in mammals;
- Learn to analyze and critically evaluate the structure and functions of vertebrate systems, which helps them to discern the developmental, functional and evolutionary history of vertebrate species.
- Understand the importance of comparative vertebrate anatomy to discriminate human biology.

Course Content:
Theory [Credits: 4] 60 hrs

Unit1: Integumentary System 7hrs

Structure and derivatives of integument, functions of skin.

(Chapter 6: K.V.Kardong; Chapter 6: G.C. Kent)

Unit2: Skeletal System 9 hrs

Outline of axial and appendicular skeleton: basic plan of bones of skull, girdles and limbs. Classification of vertebrae, structure of a typical vertebra, Jaw suspensorium, Visceral arches.

(Chapter 7, 8 and 9: K.V.Kardong; Chapter 7, 8, 9 and 10: G.C.Kent)

Unit 3: Digestive System 8 hrs

Alimentary canal and associated glands, dentition

(Chapter 13; K.V.Kardong; Chapter 12: G.C. Kent)

Unit 4: Respiratory System 8hrs

Skin, gills, lungs and air sacs; Accessory respiratory organs

(Chapter 11: K.V.Kardong; Chapter 13:G.C.Kent)

Unit 5: Circulatory System 8hrs

General plan of circulation, Evolution of heart and aortic arches

(Chapter 12: K.V. Kardong; Chapter14: G.C.Kent)

Unit 6: Urinogenital System 6 hrs

Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri.

(Chapter 14: K.V. Kardong; Chapter 15:G.C.Kent)

Unit 7: Nervous System 8 hrs

Comparative account of brain; Autonomic nervous system, Spinal cord, Cranial nerves in mammals

(Chapter 16 : K.V. Kardong ; Chapter 16 :G.C. Kent)

Unit 8: Sense Organs 6 hrs

Classification of receptors; Brief account of visual and auditory receptors in man

(Chapter 17:K.V.Kardong; Chapter 17:G.C. Kent)

Practical [Credits: 2]

1. Study of placoid, cycloid and ctenoid scales of fish through permanent slides/photographs.
2. Study of different types of feathers of birds.
3. Disarticulated skeleton of Frog, *Varanus*, Fowl, Rabbit (Skull, Limb bones, Vertebral Column, Sternum, Girdles, Ribs).
4. Carapace and plastron of turtle/tortoise.
5. Mammalian skulls: One herbivorous and one carnivorous animal.
6. Study of digestive, circulatory and urinogenital system of frog/rat through videos on dissection or through virtual dissections.
7. Study of anatomical details of any two organs (brain, heart, lung, kidney, eye and ear) through videos.
8. Project on modifications in skeletal structures/GI tract/Respiratory organs in vertebrates.
9. Documentary film show on vertebrates/Visit to Zoological park, Biodiversity park or Sanctuary.

Teaching and Learning Process:

In order to ensure best understanding of concepts and learning of skills by students, various strategies will be adopted to explore and compare the major vertebrate groups. Class room lectures and crossover learning will provide a conceptual foundation to the leaner and will bridge the informal learning to formal learning. Use of models and computer-assisted learning by showing photographs/diagrams/models/animations/videos will help to clarify theoretical as well as practical concepts, from referred textbooks and E-resources available in NCBI, SWAYAM etc. Project work will encourage students to undertake projects on certain topics like modifications in GI tract, appendages, respiratory organs etc. with respect to different habitats. Peer teaching including presentation and group discussions on various topics of vertebrate comparative anatomy will allow effective participation of students in class room and develop confidence in students. Computer-aided methods by showing virtual dissections or videos of anatomy of circulatory, digestive and reproductive systems of frog and rat, will provide an understanding of animal systems.Viewing documentary films or visiting biodiversity parks, aquarium, sanctuaries and zoological parks will help students correlate the anatomical changes in the vertebrates studied in the classroom with actual observation in living animals. Assignments will improve the writing and abstracting skills of students.

Assessment Methods:

- Formative assessment on regular basis: This includes putting up questions in order to monitor students' learning. Students are marked on the basis of continuous assessment and end term exam.
- Continuous assessment: includes class test, assignment and attendance.
- Marks for the attendance: to maintain regularity in the class.
- Practical: provide a great opportunity to assess students for their understanding about a concept lectured, and demonstrate activity in small groups. Additionally, regular assessment of the practical skills gained by students can also be done.
- Summative assessment: includes project reports, assignments, oral presentations, *viva-voce*, evaluation of practical records, regular tests.

Keywords:

Anatomy, integument, axial, appendicular, cranium, jaw suspensorium, pectoral and pelvic girdle, visceral arches, dentition, air sacs, accessory respiratory receptors, visual,cranial, spinal nerves,

RecommendedBooks:

- Kardong, K.V. (2005). Vertebrate's Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
- Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.
- Leiem C.F., Bermis W.E, Walker, W.F, Grande, L. (2001). Functional anatomy of the vertebrates, An evolutionary perspective. III Edition, Brookes/Cole, Cengage Learning.

Suggested Readings:

- C.K Weichert and W. Presch (1970). Elements of Chordate Anatomy, IV Edition, McGraw-Hill.
- Pough.H. (2018). Vertebrate Life.X Edition. Pearson International.

Online Tools and Web Resources:

- SWAYAM (Functional anatomy and regulation of vision, hearing, taste, smell and touch, Link - https://www.swayamprabha.gov.in/index.php/program/upcoming/9).
- SWAYAM (Structure of heart), Link- https://www.swayamprabha.gov.in/index.php/program/archive/9.
- COURSERA (PALEONTOLOGY: Early vertebrate evolution, Link – https://www.coursera.org/learn/early-vertebrate-evolution).

ZHCore IX: Physiology: Life Sustaining Systems

Course Learning Objective:

Physiology is the study of life, specifically, how cells, tissues and organ function. It is a core and fundamental scientific discipline that defines the health and well-being of living organisms. Besides satisfying a natural curiosity about how our body systems function, it gives us knowledge about the functions of all the parts and systems of the body. It is also of central importance in medicine and health sciences. The course has been designed to apply the theoretical concept to the laboratory exercises for acquiring skills. The fundamental or coherent understanding of the subject will be extended to related disciplinary areas/subjects through understanding of normal body functions, enabling effective treatment of abnormal or diseased states. The students will be equipped with skill-based knowledge to help them undertake further studies in physiology and related areas as well as in multidisciplinary subjects.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Have a clear knowledge of basic fundamentals and understanding of advanced concepts so as to develop a strong foundation that will help them to acquire skills and knowledge to pursue advanced degree courses.
- Comprehend and analyse problem-based questions on physiological aspects.
- Recognize and explain how all physiological systems work in unison to maintain homeostasis in the body; and use of feedback loops to control the same.
- Learn an integrative approach to understand the interactions of various organ systems resulting in the complex overall functioning of the body.

Course Content:
Theory [Credits: 4] 60 hrs

Unit 1: Physiology of Digestion 16 hrs

Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinal tract.

(*Chapter 24: Tortora)*

Unit 2: Physiology of Respiration 12 hrs

Histology of respiratory tract; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration.

(*Chapter 23: Tortora)*

Unit 3: Renal Physiology 12 hrs

Structure of kidney and its functional Unit; Mechanism of urine formation; Regulation of water balance; Regulation of acid-base balance.

(*Chapter 26 and27: Tortora)*

Unit4: Blood 8 hrs

Components of blood and their functions; Structure and functions of haemoglobin; Haemostasis: Blood clotting system, Kininogen Kinin system, Fibrinolytic system.
(*Chapter 19: Tortora*)

Unit 5: Physiology of Heart 12 hrs
Structure of mammalian heart; Coronary circulation; Structure and working of conducting myocardial fibers. Origin and conduction of cardiac impulses; Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate. Electrocardiogram, Blood pressure and its regulation.
(*Chapter 20 and 21: Tortora)*

Practical [Credits: 2]

1. Enumeration of red blood cells and white blood cells using haemocytometer
2. Estimation of haemoglobin using Sahli's haemoglobinometer
3. Preparation of haemin and haemochromogen crystals
4. *Interpretation of recording of frog's heart beat (*in situ*) under normal and experimental conditions.
5. *Recording of blood pressure using a sphygmomanometer
6. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney
7. Study of lung volumes and capacities by Spirometry; Comparison of normal physiological and one pathological condition.

(*Subject to UGC guidelines)

Teaching and Learning Process:

The Learning Outcomes-Based Approach to curriculum planning and execution requires that the teaching learning processes are oriented towards enabling students to attain the defined learning outcomes relating to the courses within a programme. This, particularly in the context of undergraduate studies, requires a significant shift from teacher centric tolearner/ student centric, pedagogies and from passive to active /participatory pedagogies. Therefore, planning for teaching becomes critical. Practical skills, including an appreciation of the link between theory and experiment, will constitute an important aspect of the teaching-learning process. Teaching methods will include:

- Lectures supported by group tutorial work; invited lectures
- Practical and field-based learning;
- The use of prescribed textbooks and e-learning resources and other self-study materials;
- Project work
- Assignments, seminars, oral presentations
- Activities designed to promote the development of generic/transferable and subject specific skills;
- Internships and visits to field sites and hospitals or other research facilities
- Guidance by the 'mentors' and specialists in the field etc.

Assessment Methods:

A variety of assessment methods will be used to assess progress towards the course learning outcomes. Priority will be accorded to formative assessment. Progress towards achievements of learning outcomes will be assessed using the following:

- Theory and practical examinations,Problem based assignments;
- Practical assignment, laboratory exercises and reports; observation of practical skills;

- Individual project reports (case-study reports); team project reports;
- Oral presentations, including seminar presentations; viva voce interviews;
- Peer and self-assessment, literature survey evaluations etc.

Keywords:

Gastrointestinal Tract, Absorption, Respiratory Volumes and Capacities, Oxy-haemoglobin curve, Nephron, Countercurrent mechanism, Acid -base Balance, Haemostasis, Coronary circulation, Pacemaker, ECG, Cardiac cycle, Heart sounds, Frank-Starling Law, Blood pressure.

Recommended Books:

- Tortora, G.J.& Grabowski, S (2006) Principles of Anatomy & Physiology, XI edition.John Wiley & Sons
- Vander A, Sherman J, and Luciano D (2014). Vander's Human Physiology: The mechanism of Body Function. XIII Edition, Mc Graw Hills.

Suggested Readings:

- Ganong W.F. (2019). Review of Medical Physiology 26th ed Mc Graw-Hill,
- Guyton, A.C & Hall, J.E. (2006).Textbook of Medical Physiology, XI Edition. Hercourt Asia PTE Ltd/W.B. Saunders Company
- Marieb E.N. (1998). Human Anatomy and Physiology, 4th Ed, Addison Wesley Longman, Inc.

Online Tools and Web Resources:

- e portals like SWAYAM
- http://nsdl.niscair.res.in

ZH Core-X: Biochemistry of Metabolic Processes

Course Learning Objective:

The program is designed to enable a student acquire sound knowledge of biochemistry and its practicable applicability. Effort has been madeto make the study relevant, interesting and encouraging to the students to join the industry or to prepare them for higher studies including research. The new and updated syllabus is based on a basic and applied approach to ensure that students develop problem solving skills, laboratory skills, chemistry communication skills, team skills as well as ethics.

Course Learning Outcome:

Upon completion of the course, students will be able to

- Gain knowledge and skill in the interactions and interdependence of physiological and biomolecules
- Understand essentials of the metabolic pathways along with their regulation.
- Know the principles, instrumentation and applications of bioanalytical techniques.
- Get exposure to various processes used in industries.
- Become aware about classical laboratory techniques, use modern instrumentation, design and conduct scientific experiments and analyze the resulting data.
- Be knowledgeable in proper procedures and regulations in handling and disposal of chemicals

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Overview of Metabolism 10 hrs

Catabolism *vs.* Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways; Errors in metabolism.

(Chapter 15: Cox, M.M and Nelson, D.L; Chapter 14:Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Unit 2: Carbohydrate Metabolism 16 hrs

Sequence of reactions and regulation of glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.

(Chapter 14 and 16: Cox, M.M and Nelson, D.L.; Chapter 16 and 17: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Unit 3: Lipid Metabolism 12 hrs

β-oxidation and omega-oxidation of saturated fatty acids with even and odd number of carbon atoms and their regulation; Biosynthesis of palmitic acid; Ketogenesis.

(Chapter 17: Cox, M.M and Nelson, D.L; Chapter 22: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Unit 4: Protein Metabolism 8 hrs

Catabolism of amino acids: Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids.

(Chapter 18: Cox, M.M and Nelson, D.L.; Chapter 23: *Berg, J.M., Tymoczko, J.L. and Stryer, L.)*

<u>Unit 5</u>:Oxidative Phosphorylation 10 hrs

Redox systems; Review of mitochondrial respiratory chain:Electron carriers, sites of ATP production, inhibitors and un-couplers of Electron Transport System, Oxidative phosphorylation: structure of ATPase complex, Chemiosmotic hypothesis, mitochondrial shuttle system and membrane transporters.

(Chapter 19: Cox, M.M and Nelson, D.L.; Chapter 18: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

<u>Unit 6:</u> Liver as Major Metabolic Hub 4 hrs

Inter-connection of glucose-6-phosphate, pyruvate and acetyl-CoA; Fates of amino acids, fatty acids and glucose in liver cells; Cascade of metabolic events in fasting and starvation.

(Chapter 16: Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A.; Chapter 30: Berg, J.M., Tymoczko, J.L. and Stryer, L.)

Practical [Credits: 2]

1. Estimation of total protein in given solutions by Lowry's method.
2. Detection of SGOT and SGPT or GST and GSH in serum/ tissue
3. To study the enzymatic activity of Trypsin and Lipase.
4. Study of biological oxidation (SDH) [goat liver]
5. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.
6. Dry Lab: To trace the labelled 'C' atoms of Acetyl-CoA till they evolve as CO_2inthe TCA cycle through models
7. To estimate the bilirubin by clinical method and to know the physiological significance of the bilirubin

Teaching and Learning Process:

At the end of the IV Semester, the UG student is expected to demonstrate clear understanding of general concepts and fundamental biochemical principles; such as structure/function of biomolecules metabolic pathways, regulation of biological and biochemical processes through class room lectures and encourage interactive learning with simulation studies including animations, presentations. Principles of various biochemical techniques will be explained through advanced instrumentations. The data will be analysed and interpreted with computer-assisted software. Project-based studies will help students devise experiments independently.

Assessment Methods:

- Continuous Assessment by regular class tests; Projects and Assignments both individual/group projects to inculcate independent thinking as well as team work among the students. Regular Presentations to be assessed based on the content, novelty, explanation and response to queries.
- Online Assignment/Project Submission; Self-assessment through Quiz.
- Concept maps (Diagram with hierarchical nodes, labeled with concepts), Concept (The instructor presents one or more questions during class along with several possible answers), Oral/Poster Presentation.
- Use of free video recording tool and online video platform (such as PresentationTube; http://presentationtube.com/). It helps to connect and train teachers and students to record, publish, and share quality video tutorials.

Keywords:

Metabolism, Catabolism, Anabolism, Oxidative phosphorylation, Electron Transport System, ATPase, Liver, Fatty acids

Recommended Books:

- Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry. VEdition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry. VI Edition,W.H. Freeman and Co., New York.

Suggested Readings:

- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. andWell, P.A. (2009). Harper's Illustrated Biochemistry. XXVIII Edition,International Edition, The McGraw-Hill Companies Inc.
- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, IIEdition, BIOS Scientific Publishers Ltd., U.K.

Online Tools and Web Resources:

- CECGurukul (www.cec.nic.in) and their YouTube webpage (https://www.youtube.com/user/cecedusat/featured)
- https://swayam.gov.in/courses/5638-biochemistry

ZH Core-XI: Molecular Biology

Course Learning Objective:

The course aims to provide students with an introduction of the underlying molecular mechanisms of various biological processes in cells and organisms. The study primarily involves learning about structure and synthesis of deoxyribo- and ribo-nucleic acids, formation of proteins, and regulation of gene expression.The course aims to develop basic understanding of structure-function relationships of nucleic acids and proteins.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Describe the basic structure and chemistry of nucleic acids, DNA and RNA;
- Compare and contrast DNA replication machinery and mechanisms in prokaryotes and eukaryotes.
- Elucidate the molecular machinery and mechanism of information transfer processes– transcription and translation-in prokaryotes and eukaryotes;
- Explain post-transcriptional modification mechanisms for the processing of eukaryotic RNAs;
- Discuss general principles of transcription regulation in prokaryotes by exploring the structure and function of lactose and tryptophan metabolism operons;
- Give an overview of gene expression regulation in eukaryotes;
- Explain the significance of DNA repair mechanisms in controlling DNA damage;
- Recognise role of RNAs (riboswitches, siRNA and miRNA) in gene expression regulation.
- Demonstrate practical knowledge of raising, handling, maintenance and special features such as antibiotic resistance of a simple prokaryotic model organism, *Escherichia coli*.
- Quantitatively estimate concentration of DNA and RNA by colorimetric methods.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Nucleic Acid 6 hrs

Salient features of DNA and types of RNA (mRNA, rRNA and tRNA); Watson and Crick model of DNA

(Chapter 6: Watson; Chapter 18: Becker)

Unit 2: DNA Replication 12 hrs

DNA replication in prokaryotes and eukaryotes – replication machinery and mechanisms, semi-conservative, bidirectional and semi-discontinuous replication, Replication of circular and linear double stranded DNA, Replication of telomeres.

(Chapter 8: Watson; Chapter 19: Becker)

Unit 3: Transcription 10 hrs

Machinery and mechanism of transcription in prokaryotes and eukaryotes-RNA polymerases, Transcription unit, Transcription factors, Synthesis of rRNA.

(Chapter 12: Watson; Chapter 21: Becker)

Unit 4: Translation 12 hrs

Genetic code, Degeneracy of the genetic code and Wobble hypothesis; Process of protein synthesis in prokaryotes: Ribosome structure, fidelity of protein synthesis, aminoacyl-tRNA synthetases and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain, Inhibitors of protein synthesis; Difference between prokaryotic and eukaryotic translation.
(Chapter14: Watson; Chapter21 and 22: Becker)

<u>Unit 5:</u> Post Transcriptional Modifications and Processing of Eukaryotic RNA 4 hrs
Split genes: concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing.
(Chapter 13: Watson)

<u>Unit 6:</u> Gene Regulation 10 hrs
Transcription regulation in prokaryotes: Principles of transcriptional regulation with examples from *lac* operon and *trp* operon; Overview of transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements; Gene silencing and Genetic imprinting.
(Chapter 16 and 17: Watson; Chapter 22: Becker)

<u>Unit 7:</u> DNA Repair Mechanisms 2 hrs
Pyrimidine dimerization and mismatch repair.
(Chapter 9: Watson)

<u>Unit 8:</u> Regulatory RNAs 4 hrs
Ribo-switches; RNA interference: miRNA and siRNA.
(Chapter 18: Watson)

Practical [Credits: 2]

1. Study of Polytene chromosomes from *Chironomous/ Drosophila* larvae.
2. Preparation of liquid culture medium (LB) and raise culture of *E. coli*.
3. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking.
4. Estimation of the growth kinetics of *E. coli* by turbidity method.
5. Demonstration of antibiotic sensitivity/resistance of *E. coli* to antibiotic pressure and interpretation of results.
6. Quantitative estimation of salmon sperm/calf thymus DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A260 measurement).
7. To understand working of the *lac* operon in the presence/absence of lactose and/or glucose by using simulations.
8. Study and interpretation of electron micrographs/ photograph showing: DNA replication, Transcription, Split genes.

Teaching and Learning Process:

It is important for any course to enhance conceptual understanding of the subject content in the students, provide related hands-on training as well as aid in developing required skill-set for making them advance towards a field of choice. Molecular Biology course is designed to equip students with a strong foundation in molecular mechanisms of biological processes which instigates a plethora of ideas in them that will motivate them to pursue advance research. Practical exercises further provide them with required basic molecular microbiology laboratory training that will build in them confidence and make them competent to pursue advance research in this field in India or abroad. Apart from the enriched content, use of teaching learning methodologies such as active learning, inquiry-based learning, project learning, peer learning etc. in the classrooms will help in developing higher order thinking skills of analysing, evaluating and creating knowledge. Further usage of general and specific information & communications technology (ICT) and digital tools such as projectors, simulations, scientific games, etc. will make the teaching learning process most rewarding an experience.

Assessment Methods:

Any teaching method needs to be matched by an appropriate assessment that relates to the objectives of the teaching. Thus, it is important to ensure that our molecular biology curriculum matches the teaching that occurs and the assessments we make. Students may or may not learn what is in the curriculum or what we teach, but they will learn what we assess them.

- Assessment based on project work, quiz, problem solving exercise, practical assignment, laboratory reports, presentation, *viva-voce*, computerized adaptive testing, and literature surveys by end-semester examination etc.are reliable and valid measure of a student's performance, and can be relatively easily used to assess the final cumulative performance.
- It is also important to identify the focus areas required for individual student study and ranks student performance.

Keywords:

DNA, RNA, nucleic acids, replication, transcription, translation, RNA processing, regulation of gene expression, *lac* operon, attenuation, splicing, RNA interference, riboswitches

Recommended Books:

- Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene.VI edition. Cold Spring Harbour Lab. Press, Pearson Pub.
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
- Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.

Suggested Readings:

- Cooper G. M. and Robert E. Hausman R. E. The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.
- Lewin B. (2008). Gene XI. Jones and Bartlett.
- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter: Molecular Biology of the Cell, IV Edition.

Online Tools and Web Resources:

- https://swayam.gov.in/courses/5065-molecular-biology
- https://swayam.gov.in/courses/4916-molecular-biology
- https://www.youtube.com/user/cecedusat

ZH Core Course XII: Principles of Genetics

Course Learning Objective:

Unknown to them, human beings had been applying the principles of genetics by engaging in selective breeding of domesticated animals for many centuries. However, it was only with the work of Mendel and advent of 20^{th} century, that basic principles of the science of genetics were formulated. In about a century of its existence, this field has generated tremendous amount of knowledge through observational and experimental research. The information amassed in the last century has laid the foundation for more discoveries in this important field of life science. This course aims to provide an overview of genetics starting from the work of Mendel to the current understanding of various phenomena like recombination, transposition, sex determination and mutations. The course will help in building sound fundamental knowledge of the principles of genetics, to be used as a stepping stone for higher studies and research in this field.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Have a deeper understanding of the varied branches of the biological sciences like microbiology, evolutionary biology, genomics and metagenomics.
- Gain knowledge of the basic principles of inheritance.
- Analyse pedigree leading to development of analytical skills and critical thinking enabling the students to present the conclusion of their findings in a scientific manner.
- Know the mechanisms of mutations, the causative agents and the harmful impact of various chemicals and drugs being used in day to day life.
- Find out the effects of indiscriminate use of various chemicals, drugs or insecticides in nature by studying their effect on various bacterial species in soil and water samples from different industrial or polluted areas.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Mendelian Genetics and its Extension 10hrs

Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, penetrance and expressivity, Epistasis, Pleiotropy, Sex-linked, sex-influenced and sex-limited characters inheritance and concept of gene.

(Chapter 3 and 4: Klug and Cummings; Chapter 3, 4, 5: Benjamin A. Pierce; Chapter 3, 4: Snustad and Simmons)

Unit 2: Linkage, Crossing Over and Chromosomal Mapping 10 hrs

Linkage and crossing over, Cytological basis of crossing over, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Linkage map, coefficient of coincidence and Interference, Gene mapping by Somatic cell hybridization.

(Chapter 5: Klug and Cummings; Chapter 7: Benjamin A. Pierce; Chapter 7: Snustad and Simmons)

Unit 3: Mutations 10 hrs

Types of gene mutations, Detection of mutations in *Drosophila*: CLB method, attached X method, Mutagens: Physical and Chemical, Molecular basis of spontaneous and induced mutations, Chromosomal aberrations: Variations in number and structure.

(Chapter 8, 15: Klug and Cummings; Chapter 9, 18: Benjamin A. Pierce; Chapter 6, 13: Snustad and Simmons)

Unit 4: Sex Determination 5 hrs

Basis of sex determination: Genetic and environmental; Sex determination in *Drosophila* and Man; Mechanism of dosage compensation.

(Chapter 7: Klug and Cummings; Chapter 4: Benjamin A. Pierce; Chapter 5: Snustad and Simmons)

Unit 5: Extra-chromosomal Inheritance 5hrs

Comparison of nuclear and extra nuclear inheritance; Organelle inheritance: Antibiotic resistance in *Chlamydomonas*, Mitochondrial mutations in *Saccharomyces* and human disorders, Infective heredity in *Paramecium.* Maternal effects: Shell coiling in *Limnaea*, pigmentations in *Ephestia.*

(Chapter 9: Klug and Cummings; Chapter 20: Gardner, Simmons and Snustad)

Unit 6: Polygenic Inheritance 3hrs

Polygenic inheritance with suitable examples and numericals

(Chapter 23: Klug and Cummings; Chapter 21: Gardner, Simmons and Snustad; Chapter 22: Benjamin A. Pierce)

Unit 7: Recombination in Bacteria and viruses 9 hrs

Conjugation, Transformation, Transduction in bacteria, Complementation test in Bacteriophage

(Chapter 6: Klug and Cummings; Chapter 8: Benjamin A. Pierce; Chapter 7: Snustad and Simmons; Chapter 8: Gardner, Simmons and Snustad)

Unit 8: Transposable Genetic Elements 8hrs

Transposons in bacteria, Ty elements in yeast, Ac-Ds elements in maize and P elements in *Drosophila*, Transposons in humans, Transposons as mutagens

(Chapter 15: Klug and Cummings; Chapter 11: Benjamin A. Pierce; Chapter 17: Snustad and Simmons; Chapter 16: Russell; Chapter 16: Griffith)

Practical [Credits: 2]

1. Simulation exercises using beads or seeds to study the Mendel's laws and gene interactions.
2. Verification of Mendelian ratios using Chi-square analysis/test.
3. Pedigree analysis.
4. Use of probability in solving problems in genetics.
5. Linkage maps based on data from conjugation.
6. Linkage maps based on data from *Drosophila* crosses.
7. Study of human karyotype (normal and abnormal).

Teaching and Learning Process:

Lectures, using blackboard and power-point presentations will be delivered by the teachers and the queries of students will be addressed after they have revised the topic. Concepts can be clarified by giving assignments e.g. constructing linkage maps, pedigree analysis, probability calculations etc. As a part of peer learning, regular group discussions will be held amongst the students to enhance their knowledge. In order to develop scientific temperament and hone communication skills of students, power point presentations, paper presentations and debates can be organized on various themes as prescribed in the syllabi, while focusing on the latest development in them. An essential part of learning is through observation and experimentation. Thus, visit of students to laboratories working in the field of Genetics (e.g. *Drosophila*, microbial genetics) can be organized. Also, students can be encouraged to undertake internships in these labs so as to deepen their interest in this field. Lectures of researchers can be organized to update students about the latest developments in this field, so that they get motivation to make a career in this highly versatile field of biological sciences.

Assessment Methods:

Students can be assessed by following methods for proper understanding of the subject.

- Problem solving assignments.
- Assessment of case history projects to prepare pedigrees and find out the probabilities of occurrence of diseases in next generations.
- Power point presentation evaluation on different topics.
- Holding debates and assessment for understanding of the subject.
- Multiple choice questions (Test) for assessing grasping of the topics.
- Laboratory visits to understand the research going on in the field of Genetics and to submit reports.

Keywords:

Mendelian inheritance, Multiple alleles, Penetrance, Epistasis, Pleiotropy, Gene, Chromosomal mapping, Recombination, Interference, Mutagens, chromosomal aberrations, Sex determination, Dosage compensation, Nuclear inheritance, Mitochondrial inheritance, Polygenic inheritance, Complementation, Transposons, Ty elements, Ac-Ds elements.

Recommended Books:

- Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons In.
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cumming
- Pierce B. A. (2012). Genetics-A Conceptual Approach. IV Edition. W. H. Freeman and Company

Suggested Readings:

- Russell, P. J. (2009). Genetics- A Molecular Approach.III Edition. Benjamin Cummings
- Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. Introduction to Genetic Analysis. IX Edition. W. H. Freeman and Co.
- Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. VIII Edition. Wiley India

Online Tools and Web Resources:

- https://swayam.gov.in/courses/4922-genetics-and-genomics
- https://www.coursera.org/learn/genetics-evolution
- https://onlinelearning.hms.harvard.edu/hmx/courses/hmx-genetics/
- https://learn.genetics.utah.edu/

ZH Core Course-XIII: Developmental Biology

Course Learning Objective:

The main aim of the paper on Developmental Biology is to provide the undergraduate students an in-depth knowledge on the embryonic and post embryonic developmental processes. An important aspect of developmental biology is its implication in medicine which is also dealt with in this course. The approach of this paper is to make the students realize the most fascinating aspect of developmental biology that a single fertilized egg can give rise to a fully developed complex organism. The course explains the basic principles and concepts underlying the developmental processes at the cellular and molecular level. To understand morphogenesis, the students are introduced to model organisms like Sea urchin, *Drosophila,* Frog and Chick to study different types of eggs, cleavage patterns and various morphogenetic movements during gastrulation leading to formation of germ layers and their fate. By understanding the developmental processes, the students can relate to errors occurring during development leading to congenital disorders and human diseases. The paper also addresses the problems of infertility in humans. The students are familiarized with the technique of IVF and pre-diagnostic methods to identify any abnormality arising during development. The students are made aware of the areas of great interest including stem cell therapy, tissue engineering and regenerative medicine.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Understand the events that lead to formation of a multicellular organism from a single fertilized egg, the zygote.
- Acquire basic knowledge of the cellular processes of development and the molecular mechanisms underlying these.
- Describe the general patterns and sequential developmental stages during embryogenesis; and understand how the developmental processes lead to establishment of body plan of multicellular organisms.
- Discuss the general mechanisms involved in morphogenesis and to explain how different cells and tissues interact in a coordinated way to form various tissues and organs.
- Understand about the evolutionary development of various animals.
- Know the process of ageing leading to interventions that can improve the overall health and quality of life in aged people.
- Learn the importance of latest techniques like stem cell therapy, *in vitro* fertilization and amniocentesis etc. to be applied for human welfare.
- Develop the skill to raise and maintain culture of model system; *Drosophila* in the laboratory.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Introduction 4 hrs

Historical perspective and basic concepts: Phases of development, cell-cell interaction, pattern formation, differentiation and growth, differential gene expression, cytoplasmic determinants and asymmetric cell division

(Chapter 1: Gilbert, S.F.; Chapter 1: Balinsky, B.I.; Chapter 1: Wolpert, L.)

Unit 2: Early Embryonic Development 26 hrs

Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula; Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers

(Chapter 4, 5, 7 and 8: Gilbert, S.F.; Chapter 2and 10:Balinsky, B.I.;Chapter 7 and 9:Slack, J.M.W.)

Unit 3:Late Embryonic Development 10 hrs

Fate of Germ Layers; Formation of neural tube, Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta)

(Chapter 8 and 9: Gilbert, S.F.; Chapter 10: Balinsky, B.I.; Chapter 9 and10: Slack, J.M.W.)

Unit 4: Post Embryonic Development 11 hrs

Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories

(Chapter 15: Gilbert, S.F.; Chapter 18 and 19: Balinsky, B.I.)

Unit 5: Implications of Developmental Biology 9 hrs

Teratogenesis: Teratogenic agents and their effects on embryonic development; *in vitro* fertilization, Stem cell (ESC), Amniocentesis.

(Chapter 17: Gilbert, S.F.)

Practical [Credits: 2]

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages): Stage 3 (Intermediate Streak)-13 hours, Stage 4 (Definitive Streak)-18 hours, Stage 5 (Head Process)-21 hours, Stage 7-24 hours, Stage 8-28 hours, Stage10-33 hours, Stage 11-40 hours, Stage 13-48 hours, Stage 19-72 hours and Stage 24-96 hours of incubation
3. Demonstration of culture of chick embryo from fertilized eggs to study various developmental stages.
4. Study of the developmental stages and life cycle of *Drosophila* from stock culture.
5. Study of different sections of placenta (photomicrographs/ slides).
6. Project report on *Drosophila* culture/chick embryo development.
7. A visit to Poultry Farm/IVF Centre

Teaching and Learning Process:

Various teaching methodologies including: interactive lectures, classroom discussions and practical exercises based on the theory paper will be employed. Video digital format will be adopted to supplement theoretical lessons and lectures presented in the classroom to stimulate discussion and increase learning. Students will be encouraged to access the e-learning resources like Swayam, Coursera etc. so that the concepts are better understood of the topics of developmental biology. Permanent slides/ photomicrographs/animations will be used for better understanding of the development processes. Educational trips such as visit to a poultry farm and dairy research institute will be conducted to enhance their understanding of the theoretical concepts. Embryological models will be employed to understand difficult concepts and relationships in development. Students can be encouraged to undertake project work on maintaining culture of *Drosophila* to observe its life cycle. Fertilized eggs of chick obtained from poultry farm can be incubated in the laboratory to study the developmental stages. Students can be motivated to engage themselves in informal discussions on various topics outside the classroom. Topics of developmental biology can be assigned for presentation so that the students improve their oral skills. The students should be encouraged for thorough self-study by encouraging them to refer to different books and on-line resources.

Assessment Methods:

- Series of tests consisting of short answer questions prepared throughout the semester related to the theory lectures.
- Group assessment of the students distributed in small groups (3-4 students) to carry out projects prepared throughout the semester.
- Continuous assessment of the students including marks for attendance, assignments and class tests.
- Level of understanding and ability to answer questions by taking *viva-voce* as a part of practical exam assessment.
- Evaluation of practical records, assignments and power point presentations.

Keywords:

Differentiation, Cytoplasmic determinants, Morphogens, Gametogenesis, Ovulation, Vitellogenesis, Graafian follicle, Embryo, Fertilization, Cleavage, Blastula, Gastrula, Epiboly, Emboly, Koller's Sickle, Organogenesis, Notogenesis, Somites, Neurula, Embryonic Induction, Placenta, Metamorphosis, Neoteny, Regeneration, Epimorphosis, Morphallaxis, Blastema, Ageing, Senescence, Teratology, Teratogens, Stem Cells, *IVF*

Recommended Books:

- Gilbert, S. F. (2010). Developmental Biology. IX Edition, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA
- Balinsky B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition, International Thompson Computer Press.
- Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell.

Suggested Readings:

- Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.
- Kalthoff, K. (2001).Analysis of Biological Development. II Edition, McGraw Hill Publishers.
- Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers.
- Arora, R. and Grover, A. (2018) Developmental Biology: Principles and Concepts. I Edition, R. Chand & Company

Online Tools and Web Resources:

- https://www.hhmi.org/biointeractive/human-embryonic-development
- https://www.khanacademy.org/science/biology/developmental-biology
- https://ocw.mit.edu/courses/biology/7-22-developmental-biology-fall-2005/index.htm
- https://embryology.med.unsw.edu.au/embryology/index.php/Main_Page

ZH Core Course XIV: Evolutionary Biology

Course Learning Objective:

The study of evolutionary biology is essential for anyone who seeks to obtain an understanding of life and natural world. It is a unifying thread which joins all organisms from prokaryotes to highest of eukaryotes. This course emphasizes on the development of evolutionary thought by dealing in general with the process and pattern of biological evolution. On one hand, it offers a chance to students to learn about deciphering evidences ranging from fossil records to molecular data and arranges them to establish phylogenetic relationships of species, while, on the other, it provides a platform to understand various forces which bring about variations among populations of a species and cause them to diversify into new species.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Acquire problem solving and high order analytical skills by attempting numerical problems as well as performing simulation studies of various evolutionary forces in action.
- Apply knowledge gained, on populations in real time, while studying speciation, behaviour and susceptibility to diseases.
- Gain knowledge about the relationship of the evolution of various species and the environment they live in.
- Get motivated to work towards mitigating climate change so that well adapted species do not face extinction as a result of sudden drastic changes in environment.
- Use knowledge gained from study of variations, genetic drift to ensure that conservation efforts for small threatened populations are focused in right direction.
- Predict the practical implication of various evolutionary forces acting on the human population in the field of human health, agriculture and wildlife conservation.
- Use various software to generate interest towards the field of bioinformatics and coding used in programming language

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Life's Beginning 7 hrs
Chemogeny, RNA World, Biogeny, Origin of photosynthesis, Endo-symbiotic theory
(Chapter 6- 9: Hall and Hallgrimson)

Unit 2: Historical Review of Evolutionary Concepts 4 hrs
Lamarckism, Darwinism, Neo-Darwinism
(Chapter 22: Campbell and Reece; Chapter 10 and 11: Hall and Hallgrimson)

Unit 3: Evidences of Evolution 12 hrs
Palaeontological: Fossils (formation, types and dating); Geological time scale; Study of horse phylogeny; Molecular: neutral theory of molecular evolution, Molecular clock, Example of globin gene family, rRNA/cyt c; Phylogenetic trees: types, interpretation and applications
(Chapter 3: Hall and Hallgrimson; Chapter 18: Ridley; Chapter 7: Pevsner)

Unit 4: Raw material for Evolution 6 hrs

Variations: Heritable variations and their role in evolution
(Chapter 4: Ridley; Chapter 4: Futuyama and Kirkpatrick)

Unit 5: Forces of Evolution: Qualitative studies 8 hrs
Natural selection, Types of selection, kin selection, adaptive resemblances, sexual selection. frequency dependent selection
(Chapter 4 and 5: Ridley; Chapter 10, 12 and 13: Futuyama and Kirkpatrick)

Unit 6: Forces of Evolution: Quantitative studies 6 hrs
Hardy-Weinberg Equilibrium: statement, assumptions, derivation of the equation; Derivation of equations for change in allelic frequencies in a population by evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, selection coefficient), genetic drift (founder's effect, bottleneck phenomenon), migration and mutation (genetic load).
(Chapter 5 and 7: Ridley; Chapter 23: Campbell and Reece)

Unit 7: Product of Evolution 8 hrs
Speciation: Micro-evolutionary changes (inter-population variations, clines, Ring species, races), Species concept, Isolating mechanisms, Modes of speciation, Adaptive radiation/macroevolution, Phyletic gradualism and punctuated equilibrium.
(Chapter 3, 13 and14: Ridley)

Unit 8: Loss of Biodiversity 3 hrs
Mass extinctions (events, causes and effects), Detailed explanation of K-T extinction
(Chapter 23: Ridley)

Unit 9: Origin and Evolution of Man 6 hrs
Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular evidences in human evolution.
(Chapter 25: Hall and Hallgrimson; Chapter 21: Futuyama and Kirkpatric)

Practical [Credits: 2]

1. Study of fossils from models/pictures.
2. Study of homology and analogy from suitable specimens.
3. Construction of cladograms based on morphological characters.
4. Construction of phylogenetic tree with the help of bioinformatics tools (Clustal X, Phylip, MLK) and its interpretation.
5. Study of variations in a sample human population: (a) Continuous variation: Height/Weight in relation to age and sex (b) Discontinuous variation: Ability/Inability to taste Phenyl thiocarbamide (PTC).
6. Study and verification of Hardy-Weinberg Law by *chi* square analysis.
7. Demonstration of role of natural selection and genetic drift in changing allelic frequencies using simulation studies.

Teaching and Learning Process:

The traditional pedagogical methods employed in the field of evolutionary biology, while building up on the information base of the students, do little to invoke a deep understanding of the various forces, mechanisms and results of evolutionary process. To inculcate a pattern of thinking which is inquisitive, scientific and focuses on seeking relationships between various cause and effects, a constructive methodology of teaching is required. While traditional lectures will be the foundation stone and walls of the teaching process, the learning process will be accentuated by providing visual stimulus through presentations which show pictorial evidence of evolution (fossils) and wildlife movies which focus on topics like sexual selection and kin selection. Regular group discussions amongst the students will enhance the learning to a great extent. Organising workshops and seminars, where eminent scientists working in the field of evolution are invited, will be a major step to draw attention of students towards the various possibilities in this field of biological science.Visits to laboratories working in the field of evolution (e.g. microbial evolution) can be very fruitful for the young learners. The saying “Nature is the best teacher” holds truest, for the science of Evolutionary Biology. One of the most important aspects of learning will be covered when field visits are organised for students to observe and study phenomenon like adaptive mimicry. A field visit to any Natural History Museum or any Geology lab having a collection of fossils is a must to inculcate a deeper understanding of the subject. While, field visits will definitely benefit the students, equal, if not more benefit will be accrued by the use of Information and Communication Technology (ICT). On one hand, students will be able to gain information about all the studies being done in this field, while on the other, they can learn to use a number of programs for establishing phylogenetic relationship between organisms. Various computer programs which offer simulation of evolutionary forces like genetic drift, natural section etc. can be used to enhance the learning in laboratory exercises.

Keywords:

Chemogeny, RNA World, Darwinism, Neo Darwinism, Fossils, Molecular Evolution, Phylogenetic Trees, Variations, Natural Selection, Mutation, Migration, Genetic Drift, Speciation, Isolating Mechanisms, Mass Extinctions, Human Evolution

Recommended Books:

- Ridley, M. (2004). Evolution. III Edition, Blackwell publishing
- Hall, B.K. and Hallgrimson, B. (2013). Evolution. V Edition, Jones and Barlett Publishers.
- Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.

Suggested Readings:

- Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition, Wiley-Blackwell
- Campbell, N.A. and Reece J.B. (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.

Online Tools and Web Resources

- https://www.coursera.org/learn/molecular-evolution
- https://www.coursera.org/learn/genetics-evolution
- https://swayam.gov.in/courses/4062-environmental-biology-genetics-and-evolution

ZH DSE Course-I: Animal Behaviour and Chronobiology

Course Learning Objective:

Animal Behaviour is the scientific study of the wild and wonderful ways in which animals interact with each other, with other living beings, and with the environment in which they live in. One important aspect pertaining to the studies on Animal Behaviour is that it can be conducted anywhere and at any time, depending on the interest of the researcher. Moreover, it is not confined to the four walls of the classroom or the laboratory. The behavioural biology has high applied value and currently linked to conservation biology, molecular biology, behavioural ecology and integrated pest management. The chronobiology addresses some periodic and cyclic nature of various life phenomena occurring in living beings in nature. They often correlate with the external environmental factors. Chronopharmacology, chronomedicine and chronotherapy are some of the direct applications of chronobiology in human health. This course aims to provide an overview of animal behaviour and chronobiology starting from historical prospective to types of behaviours and their evolutionary significance. The course also highlights types, mechanisms and importance of the biological rhythms and biological clocks operating in the living organisms. This course will help the learners to understand and appreciate different types of animal behaviours, their adaptive, evolutionary and practical significance.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Understand types of animal behaviour and their importance to the organisms.
- Enhance their observation, analysis, interpretation and documentation skills by taking short projects pertaining to Animal behaviour and chronobiology.
- Relate animal behaviour with other subjects such as Animal biodiversity, Evolutionary biology, Ecology, Conservation biology and Genetic basis of the behaviour.
- Understand various process of chronobiology in their daily life such as jet lag.
- Learn about the biological rhythm and their application in pharmacology and modern medicine.
- Realize, appreciate and develop passion to biodiversity; andy will respect the nature and environment.

Course Content:

Theory [Credits: 4] 60 hrs

<u>Unit </u>1: Introduction to Animal Behaviour 8 hrs

Origin and history of Ethology; Pioneers of Modern Ethology: Karl *von* Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen; Proximate and ultimate causes of behaviour; tools, techniques and methods used in studying animal behaviour

(Chapter 1, 2: Alcock; Section 2.3, 3.1, 3.2: McFarland)

<u>Unit </u>2: Patterns of Behaviour 10 hrs

Stereotyped behaviours (Orientation, Reflexes); Individual behavioural patterns; Instinct *versus* Learned behaviour; Associative learning, Classical and Operant conditioning, Habituation, Imprinting

(Part 2 & 3: McFarland; Chapter 2, 5: Manning)

Unit 3: Social and Sexual Behaviour 15 hrs

Social Behaviour: Concept of Society, Communication and the senses (Chemical, Tactile, Auditory, Visual); Altruism, Inclusive fitness, Hamilton's rule; Insects' society (Example: Honey bee); Foraging in honey bee and advantages of the waggle dance.

Sexual Behaviour: Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), Courtship behaviour; Parental care, sexual conflict in parental care.

(Chapter 2, 3, 4, 7 and 9: Alcock)

Unit 4: Introduction to Chronobiology 6 hrs

Historical developments in chronobiology, Biological oscillation: the concept of Average, amplitude, phase and period. Adaptive significance of biological clocks

(Chapter 2: Vinod Kumar; Chapter 1, 2: Dunlap et al; Chapter 1: Saunders)

Unit 5: Biological Rhythm 13 hrs

Characteristics of biological rhythms; Short-and Long-term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic and non-photic zeitgebers; Circannual rhythms; Photoperiod and regulation of seasonal reproduction of vertebrates; Role of melatonin.

(Chapter 2, 3, 4: Dunlap et al; Chapter 16, 17, 20: Vinod Kumar; Chapter 9: Saunders)

Unit 6: Biological Clocks 8 hrs

Relevance of biological clocks; Chronopharmacology, Chronomedicine, Chronotherapy

(Chapter 2, 3 and 4: Dunlap et al; Chapter 16, 17, 20: Vinod Kumar; Chapter 9: Saunders)

Practical [Credits: 2]

1. To study nests and nesting behaviour of the birds and social insects.
2. To study the behavioural responses of wood lice to dry and humid conditions.
3. To study geotaxis behaviour in earthworm/ phototaxis behaviour in insect larvae.
4. Study of courtship behaviour in birds and insects from short videos/films.
5. Visit to Forest/Wild life Sanctuary/Biodiversity Park/Zoological Park to study and record the behavioural activities of animals and prepare a short report.
6. Study and actogram construction of locomotor activity of suitable animal models.
7. To study circadian functions in humans (daily eating, sleep and temperature patterns).

Teaching and Learning Process:

Teaching learning methods for the Animal behaviour and chronobiology paper should include conventional black board teaching coupled with power point presentations and smart board. The animal behaviour in wild life can be shown to the student with the help of videos and short films. The classroom teaching should be inclusive and have opportunities for the students to participate in the class discussion. The students should be encouraged to observe various live animal behaviours in their immediate surrounding environment and interpret them. There should be ample scope for field visits and visit to the research laboratories. Seminar should be arranged at the departmental level for the student, where student can have paper presentation on various themes of animal behaviour and chronobiology. Quizzes and debates can be arranged to make the teaching learning more innovative. Students should be advised to use e resources along with standard text books and reference books. They should take short project work and case study on the animal behaviour. They should relate various concepts in chronobiology taught in the classroom with their daily life. The students should be regularly assessed.

Assessment Methods:

- Scheme for the assessment of students would have two components.
- The first component will include continuous evaluation of the student throughout the course work by assessing assignments, project works, presentations, quiz, class tests and regularity in attending the classes.
- The second component will carry examination carried by the University at the end of semester.

Keywords:

Animal behaviour, Types of behaviour, Social behaviour, Reproductive behaviour, Altruism, Courtship behaviour, Communication, Chronobiology, Biological rhythm, Biology Clocks

Recommended Books:

- Alcock J. (2013). Animal Behaviour. Sinauer Associate Inc., USA.
- McFarland D. Animal Behaviour. (1982). Pitman Publishing Limited, London, UK.
- Vinod Kumar (2002) Biological Rhythms. Narosa Publishing House, Delhi/ Springer-Verlag, Germany
- Dunlap J. C, Loros J. J, DeCoursey P. J. (2004) Chronobiology Biological Timekeeping.Sinauer Associates, Inc. Publishers, Sunderland, MA, USA

Suggested Readings:

- Manning, A. and Dawkins, M. S. (2012). An Introduction to Animal Behaviour. Cambridge, University Press, UK.
- Paul W. Sherman and Alcock J. (2013). Exploring Animal Behaviour. Sinauer Associate Inc., Massachusetts, USA.
- Saunders D. S. (2002). Insect Clocks. III Edition, Barens and Noble Inc. New York, USA

ZH DSE Course-II: Animal Biotechnology

Course Learning Objective:

Biotechnology is the advanced branch of biological sciences which mostly deals with technological application on biological systems. It is basically the management of biological processes for industrial and other human welfare purposes. The present paper on biotechnology attempts to give a wholesome idea of biotechnology at a basic level. It provides a tool kit in the form of a number of various techniques and processes developed over time to solve problems involving primarily human welfare with focus on health and medicine. It will equip the students with basic tools of biotechnology which are a must for everyone interested in pursuing a career in biotechnology. It makes one aware of the scope of this field which encompasses almost every field of science like engineering, research, commercialization and academics.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Use or demonstrate the basic techniques of biotechnology like DNA isolation, PCR, transformation, restriction digestion etc.
- Make a strategy to manipulate genetic structure of an organism for the improvement in any trait or its well-being based on the techniqueslearned during this course.
- Understand better the ethical and social issues regarding GMOs.
- Use the knowledge for designing a project for research and execute it.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Introduction 3 hrs

Concept and scope of biotechnology

(Chapter 1: Glick, B.R., Pasternak, J.J. and Patten, C.L.)

Unit 2: BasicTools for Gene Manipulation 12 hrs

Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics). Restriction enzymes: Nomenclature, detailed study of Type II, DNA modifying enzymes. Transformation techniques: Calcium chloride method, electroporation and biolistic method. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization

(Chapter 3: Glick, B.R., Pasternak, J.J. and Patten, C.L; Chapter 2, 4, 6, 7 and 8: Brown, T.A.)

Unit 3: Advance Tools and Techniques 18 hrs

Southern, Northern and Western blotting DNA sequencing: Sanger method, Next generation sequencing (Illumina), Polymerase Chain Reaction, DNA Finger Printing and DNA micro array, Gene Editing Tools: Zinc finger nucleases (ZFNs), transcription activator-like effector-based nucleases (TALEN) and the clustered regularly interspaced short palindromic repeats (CRISPR/Cas9) system

(Chapter 4: Glick, B.R., Pasternak, J.J. and Patten, C.L; Chapter 9, 10 and 16, Brown, T.A.)

Unit 4: Genetically Modified Organisms 18 hrs

Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection; Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock out mice.Production of transgenic plants: Agrobacterium-mediated transformation. Applications of transgenic plants: insect and herbicide resistant plants.
(Chapter 9, 16, 18, 19 and 21: Glick, B.R., Pasternak, J.J. and Patten, C.L; Chapter 15: Brown, T.A.)

Unit 5: Applications of Genetic Engineering 9 hrs
Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia), Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy
(Chapter 9: Glick, B.R., Pasternak, J.J. and Patten, C.L; Chapter 13 and 14: Brown, T.A.)

Practical [Credits: 2]

1. Genomic DNA isolation from *E.coli*
2. Plasmid DNA isolation (pUC 18/19) from *E.coli*
3. Demonstration of Restriction digestion of Plasmid/Lambda DNA.
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from calcium chloride method.
6. To demonstrate following techniques: (Optional)
   Southern/ Northern/Western blotting (Any one)
   PCR
   DNA fingerprinting
   DNA Sequencing (Sanger's Method)
7. Project report on animal cell culture OR on a visit to any biotechnology Institute

Teaching and Learning Process:

The students can have hands-on experience of basic biotechnology tools and can acquire jobs and internships in pharmaceutical companies directly after graduation and can also execute research in biotechnology. A problem-solving methodology should be employed in biotechnology education, which consists of four phases: design, production, evaluation and presentation. Various methods will be employed to make learning effective like tutorials, workshops, seminar, online assignments, questionnaires, simulation exercises and presentations. Evaluation elements in these methods will also serve to direct student learning.

Assessment Methods:

- Power Point presentation on any aspect of biotechnology instead of regular assignments.
- The project work would be assessed by the visiting examiner approved by the University.
- Students should execute one project of their choice or teacher may assign the project.
- The project report should be scanned for plagiarism check by freely available software. A soft copy of report should be mandatory.
- Semester-end and term-end examinations will carry the major assessment with regular check on students in the class.

Keywords:

Biotechnology, Gene manipulation, Vectors, Restriction Enzyme, Transformation, Blotting, Sequencing, Gene Editing, Trans-genesis, Recombinant DNA medicines, Bio-nano Technology, Gene Therapy

Recommended Books:

- Brown, T.A. (2010) Gene Cloning and DNA Analysis. VI Edition,Wiley-Blackwell publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
- Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010). Molecular Biotechnology - Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA. ISBN: 978-1- 55581-498-4 (HC).
- Primrose, S.B., and Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics.VIIEdition, Blackwell publishing (Oxford, UK) ISBN: 13: 978-1-4051-3544-3.

Suggested Readings:.

- Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007) Recombinant DNA-Genes and Genomes- A Short Course. III Edition, Freeman and Co., N.Y., USA.
- Clark, D. P. and Pazdernik, N.J. (2012) Biotechnology,,Academic Press, ISBN: 978-0-12-385063-8

Online Tools and Web Resources:

- https://swayam.gov.in/courses/5178-molecular-biology-genetic-engineering-and-plant-tissue-culture Module no.:14to 21,23&24
- https://nptel.ac.in/courses/102103041/2Gene Therapy
- https://nptel.ac.in/courses/102103013/49Genetic Engineering& Applications(Web)
- https://nptel.ac.in/courses/102107058/6Biomedical nanotechnology (Video)
- https://nptel.ac.in/courses/102107028/40Analytical Technologies in Biotechnology (Video) Electrophoresis, PCR, DNA sequencing methods
- https://www.edx.org/course?search_query=biotechnology
- https://www.coursera.org/courses?query=biotechnology&

ZH DSE Course-II: Basics of Neuroscience

Course Learning Objective:

'Neuroscience' is the branch of biology that deals with the scientific study of the nervous system- its anatomy, physiology and pathology. It deals with how the brain works and how the cells interact to control behaviour, physiology and psychology of a person. Neuroscience has become a buzz word in recent times, frequently making the headline for all manner of discoveries. Tremendous advances in neuroscience have occurred in the past two decades. The present course content is designed to give the learner a better understanding of the structure of the nervous system, as to how it works, how we sense, feel, get motivated, behave, learn and remember things/ events. In this course, students will learn various aspects of neural phenomena such as cellular, molecular and neural basis of brain rhythms, behaviour, cognition, sensation, and motivation; mechanisms and functions of emotion; learning and memory; and aspects of synaptic plasticity. This undergraduate course also covers aspects of clinical neuroscience with the aim of educating the learner in the breadth of the subject and to encourage critical thinking and evaluation of evidence. This will help undergraduates to decide whether they would wish to pursue higher studies and research in the field of neuroscience. This course also covers the finer details of neurotransmitter release, synaptic plasticity, activation of ligand-gated ion channels, receptor-mediated modulation of neuronal excitability, neurotransmitter clearance etc. This will equip the learner with a detailed insight into how the membrane excitability elicits functional effects in individual neurons and in neuronal networks as a whole. In the same manner, abnormal transmitter release/clearance, altered ion channel properties etc. will also be studied to understand their role in diseases of the nervous system.

Course Learning Outcome:

On completion of this course, the learner should be able to:

- Understand major advances in neuroscience, neural basis of emotions, behaviour, learning and memory, and how brain and behaviour can be trained/modified by experience.
- Discuss how the hypothalamus controls various behavioural patterns by releasing neurohormones/ neuropeptides in brain and periphery in response to various signals.
- Construct neural mechanisms of learning and memory (spatial and episodic memory etc.) and how specific circuits contribute to learning and memory.
- Develop an understanding about cognition, mechanism of our reaction to various situations and impact of neurological diseases on cognition.
- Understand cellular and molecular mechanisms that underlie cognition such as synaptic plasticity and organisation of memory, memory persistence and forgetfulness, the role of sleep in cognition etc.
- Gain knowledge about prion-like mechanisms responsible for the pathogenesis of common neurodegenerative diseases such as Alzheimer's, Parkinson's diseases etc.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: The Nervous system- An Introduction 4 hrs

Origins of Neuroscience; Neuron doctrine; Classification of nervous system.

(Chapter 1: Kandel, E.R; Chapter 1: Mark F. Bear; Chapter 2: Mark F. Bear)

Unit 2: Development and Anatomical Organization of the Nervous System 12 hrs

Neural tube induction, neurulation and embryonic brain development; Gross anatomy of human brain, Meninges, Ventricular System, Blood Brain Barrier, Cranial nerves; Spinal cord; Overview of peripheral nervous system (PNS).
(Chapter 7: Mark F. Bear; Appendix B: Kandel, E.R)

Unit 3: Cellular and Molecular Neurobiology 14 hrs
The prototypical neuron and classification of neurons; Electrophysiology of membrane potentials- resting and action potentials, generation and propagation; Types of Synapses, synaptic transmission and integration; EPSPs and IPSPs. Ion channels; Concept of neural coding
(Chapter 2,3,4, 5 and Page 350: Mark F. Bear)

Unit 4:Neurotransmitters and Rhythms of brain 9 hrs
Types of neurotransmitters; Transmitter gated channels; G-protein coupled receptors and effectors, neurotransmitter receptors; Ionotropic and metabotropic receptors. Electroencephalogram (EEG); Sleep neurophysiology, neural mechanisms of sleep; Neurophysiology of affection and depression;
(Chapter 6: Mark F. Bear; Chapter 12: Kandel, E.R; Chapter 19: Mark F. Bear)

Unit 5: Systems and Behavioural Neuroscience 14 hrs
Neurobiology of Behaviour (Example: Language, Sexual Orientation); Neurobiology of Perception (Example: Visual perception); Molecular basis of Learning and Memory: Classification of memory, amnesia, case of H.M., synaptic plasticity, long-term potentiation (LTP), long-term depression (LTD), memory consolidation.
(Chapter 20: Mark F. Bear; Chapter 12: Kandel, E.R; Chapter 24 and 25: Mark F. Bear)

Unit 6: Neurobiology of Neurodegenerative diseases 7 hrs
Molecular pathogenesis of Parkinson's, Alzheimer's, and Schizophrenia.Molecular mechanism (pathogenesis) of Pain including Placebo effect and Phantom limbs.Dopamine and alcohol addiction.Use of PET, CT and MRI imaging for disease diagnosis.
(Chapter 2: Mark F. Bear; Chapter 43:Kandel, E.R; Chapter 14: Mark F. Bear; Chapter 22: Mark F. Bear; Chapter 12: Mark F. Bear; Chapter 51: Kandel, E.R; Chapter 7: Mark F. Bear).

Practical [Credits: 2]

1. Study of *Drosophila* nervous system.
2. Observation and quantitation of *Drosophila* photoreceptor neurons
3. Study of Anatomy of Mammalian Brain (from slaughter house or) by using brain models (Plastic or clay medical anatomical teaching models, graphics, videos etc. can used).
4. Histological study of neurons and myelin sheath (Nissl, Giemsa or Luxol Fast Blue staining.)
5. Study of olfaction in *Drosophila*.
6. Study of novelty, anxiety and spatial learning in mice.
7. Histological study of cerebellum and spinal cord by H&E stain and cerebral cortex by Nissl stain.

Teaching and Learning Process:

'Teaching and learning' involves the process of channelizing the knowledge from the one who is *beholding* to the one who is *obtaining*. Student-centric teaching-learning process shall be the *sine qua non* of any course. To move in that direction, students will be exposed to problem solving exercises, brain puzzles, elaborative quiz-based learning. Smart classes and ICT-based teaching, including animation clips and videos, and attractive detailed pictures will be adopted. Online learning courses and practical exercises relevant to the subject will be incorporated.Organizing conferences and seminars where the students can participate in group-based learning and poster presentations will help students to clarify their concepts. Organizing visits to brain research institutes will give a glimpse of current research and techniques in neuroscience, and they will be motivated to take up mini-project works, group discussions etc.

Assessment Methods:

The learners/ students can be assessed in many different ways.

- Formative feedback throughout the course and summative feedback as mid-semester and semester-end evaluation.
- Presenting the topics in the class *via* blackboard teaching/presentations, group discussions etc.
- Students would be provided feedback on their work with a view to improve their academic performance.
- From time to time, learners will be given practical problems and neuroimages to test their theoretical skills and promote practical knowledge.
- They would be provided feedback on their work with a view to improve their academic performance.

Keywords:

Neuroscience, Neurobiology, Action potentials, Learning & memory, Synaptic plasticity, Neurotransmitters, Cognitive, Neurodegenerative diseases, Alzheimer’s disease, Parkinson’s disease

Recommended Books:

- Mark F. Bear, Barry W. Connors and Michael A. Paradiso (2015). Neuroscience: Exploring the Brain. IV Edition.
- Kandel, E.R., Schwartz, J.H. and Jessell, T.M. (2000). Principles of Neural Science. IV Edition, McGraw-Hill Companies.

Suggested Readings:

- Stephan M. Stahl-CUP (2000) Essential Psychopharamacology- Neuroscientific Basis and Practical Applications. II Edition.
- Vilayanur S. Ramachandran and Sandra Blakeslee (1998). Phantoms in the Brain
- Rita Carter (2009). The Human Brain Book

Online Tools and Online Resources

- Introduction to Neuroanatomy. Coursera online course https://www.coursera.org/lecture/neurobiology/introduction-to-neuroanatomy-22nRY
- General principles of sensory system part 1 and 2. Coursera online courses
  - ✓ www.coursera.org%2Flecture%2Fmedical-neuroscience%2Fgeneral-principles-of-sensory-systems-part-1-nwfLG,
  - ✓ www.coursera.org%2Flecture%2Fmedical-neuroscience%2Fgeneral-principles-of-sensory-systems-part-2-g7uLG

- Online lectures on Swayam (MHRD) Portal:
  - ✓ Demystifying the Brain. https://swayam.gov.in/courses/5361-jan-2019-demystifying-the-brain
  - ✓ How The Brain Creates Mind. https://swayam.gov.in/courses/4451-how-the-brain-creates-mind

ZH DSE Course-IV Biology of Insecta

Course Learning Objective:

Insects form over 70% of the faunal population on the earth. They have inhabited the earth for over 450 million years. They are the most diverse group of organisms occupying nearly all niches except for the deep sea. Learning of Morphology and Physiology of the Insects gives an overview of one of the best body designs which have survived on the earth.

Course Learning Outcome:

After completion of the course, the students will be able to:

- Appreciate the diversity of insects.
- Understand the physiology of Insects which has made them the most successful animals in terms of numbers and variety of species.
- Get a glimpse of the highly organized social life of insects.

Course Content:

Theory [Credits: 4] 60 hrs

<u>Unit 1</u>: Introduction 8 hrs

General Features of Insects; Basis of insect classification; Classification of insects up to orders; Elementary knowledge of collection, preservation and culture techniques of insects

(Chapter 1: Gullan, P. J., and Cranston, P. S.; Chapter 1 and 2: Atwal, A.S.; Vol 2; Part III: Imms, A. D.)

<u>Unit 2</u>: General Morphology of Insects 8 hrs

Head – Eyes, Types of antennae, Mouth parts w.r.t. feeding habits; Thorax: Wings: Typical structure of insect wing and its modifications, Types of Legs adapted to diverse habitat; Abdomen: Typical structure

(Chapter 1,8,9,10,14 and 27: Chapman RF.; Chapter 4 and 5: Imms, A. D.)

<u>Unit 3</u>: Physiology of Insects 30 hrs

Structure and physiology of Insect body systems (wrt cockroach)–Integumentary (structure of integument & process of moulting), digestive, excretory, circulatory, respiratory, reproductive, and nervous system; Metamorphosis: Types & hormonal control.

(Chapter 2, 9, 12, 13, 14, 15, 17 and 19: Imms, A. D. (Vol I); Chapter 3, 15, 20, 21, 22, 23, 25, 26 and 32: Chapman RF.)

<u>Unit 4</u>: Insect Behaviour 6 hrs

Social organization in insects – honey bees, termites, Insect Plant Interaction: Host-plant selection by phytophagous insects.

(Chapter 5 and 6: Wilson, E. O.; Chapter 4: Bernays, E. A., and Chapman, R. F.)

<u>Unit 5</u>: Insects as plant pests 6 hrs

Bionomics and control of following plant pests: Agricultural pests (*Papiliodemoleus, Leucinodesorbonalis, Spodopteralitura)*; Stored grain pests (*Callosobruchuschinensis, Corcyra cephalonica, Sitophilus*oryzae)

(Chapter 10, 11, 18 and 19: Atwal, A.S.; Chapter 7: Dennis, S. Hill.)

Practical [Credits: 2]

1. Study of one specimen from each insect order
2. Study of different kinds of antennae, legs and mouth parts of insects
3. Study of head and sclerites of any one insect
4. Study of insect wings and their venation
5. Study of insect spiracles
6. Methodology of collection, preservation and identification of insects
7. Morphological studies of various castes of *Apis, Camponotus* and *Odontotermes*
8. Field study of insects and submission of a project report on the insect diversity

Teaching and Learning Process:

Classroom lectures using Power point presentations enabled with related photographs of insect vectors will clarify the concepts related to insects. Group discussions on various unique physiological processes in Insects will develop interest among students to pursue higher studies in the field.Observations based on actual handling of insects and their body parts, visits to observe insects in their natural environment and entomology museum will develop curiosity among learners about insect diversity

Assessment Method:

The learners/ students can be assessed in many different ways.

- Formative feedback throughout the course and summative feedback as mid-semester and semester-end evaluation.
- Presenting the topics in the class *via* blackboard teaching/presentations, group discussions etc.
- Students would be provided feedback on their work with a view to improve their academic performance.
- From time to time, learners will be given practical problems and neuroimages to test their theoretical skills and promote practical knowledge.
- They would be provided feedback on their work with a view to improve their academic performance.

Keywords:

Insect, Vector, Diseases, Mosquito, Host, Parasite

Recommend Books:

- Imms, A. D. A.General Text Book of Entomology. Chapman & Hall, UK
- Chapman, R. F. The Insects: Structure and Function. Cambridge University Press, UK
- Snodgrass, R. E. Principles of Insect Morphology. Cornell Univ. Press, USA
- Borror, D. J., Triplehorn, C. A., and Johnson, N. F.Introduction to the Study of Insects. M Saunders College Publication, USA

Suggested Readings:

- Wilson, E. O. The Insect Societies. Harvard Univ. Press, UK
- Gullan, P. J., and Cranston, P. S. The Insects, An outline of Entomology. Wiley Blackwell, UK
- Nation, J. L. Insect Physiology and Biochemistry. CRC Press, USA

ZH DSE Course-V: Computational Biology

Course Learning Objective:

This course offers an overview of fundamental concepts of Bioinformatics and Biostatistics. An interdisciplinary program, it emphasizes integration of Computer Science with Biology and introduces the students to various computational methods and software tools for understanding biological databases, gene sequence alignments, gene annotation, protein structure predictions, drug discovery, molecular phylogeny, metagenomics, etc. The broad aim of this course is to make students get basic hands-on training and develop skill-set required for computational analysis of biological data. Recently many interest groups, such as governments, universities, research institutes and industries find Bioinformatics as a crucial area of research and development due to generation of large-scale genome sequencing data.In view of above, this course is designed to motivate the undergraduate students to pursue postgraduate program in Bioinformatics and Biostatistics.

Course Learning Outcome:

After completion of the course the students will be able to:

- Explain the basic concepts of Bioinformatics and Biostatistics and its various applications in different fields of biological sciences
- Describe theoretically sources of biological data, and list various biological databases – nucleic acids, protein sequence, metabolic pathways and small molecule
- Identify various file formats of sequence data and tools for submission of data in databases as well as retrieval of gene and protein data from databases
- Annotate gene sequence and protein structure prediction
- Perform and explain the underlying mechanisms of pair-wise and multiple sequence alignments and determine phylogenetic relationships
- Describe various computational tools and methodologies and their application in structural bioinformatics, functional genomics and *in silico* drug discovery
- Measure variability (standard deviation, standard error, co-efficient of variance) and hypothesis testing (Z-test, t-Test, chi-square test)

Course Content:

Theory [Credits: 4] 60 hrs

Unit1: Introduction to Bioinformatics 5 hrs

Goal andScope; Genomics, Transcriptomics, Systems Biology, Functional Genomics, Metabolomics, Molecular Phylogeny; Applications and Limitations of Bioinformatics
(Chapter 1: Ghosh and Mallick)

Unit2: Biological Databases 10 hrs

Introduction to biological databases; Primary, secondary and composite databases; Nucleic acid databases (GenBank, DDBJ, EMBL and NDB); Protein databases (PIR, SWISS-PROT, TrEMBL, PDB); Metabolic pathway database (KEGG, EcoCyc, and MetaCyc); Small molecule databases (PubChem, Drug Bank, ZINC, CSD)
(Chapter 3 and 4: Ghosh and Mallick; Chapter 8: Lesk)

Unit 3: Data Generation and Data Retrieval 12 hrs

Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA,

GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)
(Chapter 2 and 3: Ghosh and Mallick, Chapter 9: Lesk)

Unit 4: Basic Concepts of Sequence Alignment 14 hrs
Scoring Matrices (PAM, BLOSUM), Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Local and global alignment, pair wise and multiple sequence alignments; Similarity, identity and homology of sequences
(Chapter 6: Ghosh and Mallick, Chapter 5: Lesk)

Unit 5: Applications of Bioinformatics 9 hrs
Structural Bioinformatics (3-D protein, PDB), Functional genomics (genome-wide and high-throughput approaches to gene and protein functions), Human genome and genome wide association studies (GWAS–basic concepts), Drug discovery method (basic concepts).Machine Learning in Bioinformatics (basic concepts)
(Chapter 5 and 10: Ghosh and Mallick, Chapter 2 and 6: Lesk)

Unit 6: Biostatistics 10 hrs
Introduction: Measures of Variability, calculation of standard deviation, standard error and Co-efficient of Variance,Statistical errors, Confidence Intervals, Chi-square test, Z test, t-Test
(Chapter 3, 4, 7 and 8: Zar)

Practical [Credits: 2]

1. Accessing different biological databases
2. Retrieval of nucleotide and protein sequences from the databases.
3. To perform pair-wise alignment of sequences (BLAST) and interpret the output
4. Translate a nucleotide sequence and select the correct reading frame of the polypeptide from the output sequences
5. Predict the structure of protein from its amino acid sequence.
6. To perform a “two-sample t- test”for a given set of data
7. To learn graphical representations of statistical data with the help of computers (e.g. MS Excel).

Teaching and Learning Process:

The students will be taught theory units of this course in classrooms while practical units in Computer Laboratory/ Centres in the College. In addition to blackboard, ICT-based teaching tools, videos, animation clips, hand-outs, flow charts will be also adopted for class room teaching. Computers/laptops with high speed internet facilities will be used for practical classes. Online demonstration of each practical units will be given by the Instructor. Students will save sequence data/snapshots of the steps followed for each practical unit. Laboratory record files will be prepared for each practical unit. Students will be encouraged to participate in group discussion, seminar presentation as well as visit to Institutes of Bioinformatics or joining research internship program. Students will be trained by problem solving exercises with their computational skills.

Assessment Methods:

The students will be assessed for their performance by different means:

- Both continuous and summative assessment will be made during entire semester. Continuous assessment of students will be based on their performance in class tests, assignments.

- Students will be also assessed on the basis of power-point presentation/black-board presentation on different units of theory paper
- Summative assessment will be based on semester-end examinations of theory and practical papers.

Keywords:

Bioinformatics, Computation, Genomics, Proteomics, System Biology, Biological database, Sequence alignment, BLAST, FASTA, NCBI, EMBL, EBI, Phylogenetic tree, Drug designing, Machine Learning.

Recommended Books:

- Ghosh, Z. and Mallick, B. (2008). Bioinformatics: Principles and Applications. Oxford University Press.
- Lesk M. Arthur (2014). Introduction to Bioinformatics. Oxford University Press.
- Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition, Wiley Blackwell.
- Zar, Jerrold H. (1999). Biostatistical Analysis. IV Edition, Pearson Education Inc and Dorling Kindersley Publishing Inc. USA

Suggested Readings:

- Attwood Teressa K. and David Parry- Smith (2007). Introduction to Bioinformatics. Pearson Education.
- Mount, D. W. (2005). Bioinformatics: Sequence and Genome Analysis. CBS Publishers and Distributers Pvt. Ltd., Delhi.
- Zvelebil, Marketa and Baum O. Jeremy (2008). Understanding Bioinformatics. Garland Science, Taylor and Francis Group, USA.
- Antonisamy, B., Christopher S. and Samuel, P. P. (2010). Biostatistics: Principles and Practice. Tata McGraw Hill Education Private Limited, India.
- Pagana, M. and Gavreau, K. (2000). Principles of Biostatistics. Duxberry Press, USA
- R. Durbin, S. Eddy, A. Krogh, and G. Mitchson (1998). Biological sequence analysis: Probablistic models of proteins and nucleic acids. Cambridge University Press

Online Tools and Web Resources:

- https://www.my-mooc.com/en/categorie/bioinformatics
- https://swayam.gov.in/course/4573-bioinformatics-algorithms-and-applications
- https://www.ncbi.nlm.nih.gov/
- https://www.ebi.ac.uk/
- https://www.expasy.org/
- https://www.edx.org/course/dna-sequences-alignments-and-analysis

ZH DSE Course-VI: Endocrinology

Course Learning Objective:

The main goal of this Discipline Specific Elective (DSE) paper is to provide students with a basic understanding of human endocrine glands, neuro-endocrine glands and their structure, function and signalling pathways. Students will also study the influence of biological rhythm on hormones secretion. In addition, the course will facilitate the understanding of the biosynthesis and biochemistry of hormones. Also, emphasis would be laid on understanding the maintenance of homeostasis by the hormones. The course will also try to integrate the basic and clinical aspects of endocrinology to enhance the understanding of students about the consequences due to hyposecretion, hypersecretion and absence of hormones leading to various diseases and metabolic disorders.

Course Learning Outcome:

After completion of the course the students will be able to:

- Understand endocrine system and the basic properties of hormones.
- Appreciate the importance of endocrine system and the crucial role it plays along with the nervous system in maintenance of homeostasis.
- Gain insight into the molecular mechanism of hormone action and its regulation.
- Knowthe regulation of physiological process by the endocrine system and its implication in diseases.
- Gain knowledge about the prevalent endocrine disorders and critically analyze their own and their family`s health issues.

Course Content:

Theory [Credits: 4] 60 hrs

<u>Unit 1</u>: Introduction to Endocrinology 8hrs

Overview of the endocrine system, Classification of hormones and their synthesis, Transport of Hormones, Metabolism of hormones and their half-lives.

(Chapter 3 and 4: David O. Norris; Chapter 1 and 2: Anthony W. Norman and Gerald Litwack)

<u>Unit 2</u>: Neuroendocrinology 15 hrs

Structure of pineal gland, Secretions and their functions in biological rhythms and reproduction.Structure of hypothalamus, Hypothalamic nuclei and their functions, Regulation of neuroendocrine glands, Feedback mechanisms, Structure of pituitary gland, Hormones and their functions, Hypothalamo-hypophyseal portal system, Disorders of pituitary gland

(Chapter 4: David O. Norris; Chapter 3: Anthony W. Norman and Gerald Litwack)

<u>Unit 3</u>: Peripheral Endocrine Glands 25 hrs

Functional histology and Regulation of Thyroid, Parathyroid, Adrenal, Endocrine Pancreas, Gonads; Disorders related to hypersecretion and hyposecretion of hormones

(Chapter 5, 6, 10, 11, 12, 13: Anthony W. Norman and Gerald Litwack)

<u>Unit4</u>: Molecular Endocrinology 12 hrs

Hormone receptors, Transduction and regulation Hormone action at Molecular level: Molecular mediators (GPCR Family; DAG-Calcium Signaling Systems; RTKs, Protein Kinases and Phosphatases in Cellular Signaling); Steroid Hormone Receptor Families.

(Chapter 1: Anthony W. Norman and Gerald Litwack; Chapter 2, 3, 4: Jameson and Groot)

Practical [Credits: 2]

1. Dissect and Display of Endocrine glands in laboratory bred rat*/Human model
2. Study of the permanent slides of all the endocrine glands
3. Compensatory ovarian/adrenal hypertrophy *in vivo* bioassay in laboratory bred rat*
4. Demonstration of Castration/ ovariectomy in laboratory bred rat*
5. Estimation of plasma level of any hormone using ELISA
6. Chromatographic separation of steroid hormones using paper chromatography
7. Survey based project on any prevalent endocrine disorder
   *Depending on availability as per UGC guidelines

Teaching and Learning Process:

Lecture using Power Point and chalk-blackboard method will clarify the concepts of endocrinology. Use of ICT facility and survey based short projects as assignments will create interest among students to explore further. Visit to Prominent endocrinology laboratory will help students to learn about basic techniques.

Assessment Methods:

- Formative assessment in the form of quizzes, multiple choice questions, fill in the blanks and short answers
- Student presentation
- Take-home Assignments
- Summative assessment in the form of end of term Theory and Practical examination

Keywords:

Endocrine glands, hormone, neuroendocrinology, hypersecretion, hyposecretion, Receptors, second messenger, signal transduction, homeostasis

Recommended Books:

- J. Larry Jameson Leslie De Groot (2010). Endocrinology. VI Edition.
- David O. Norris. Vertebrate Endocrinology. V Edition,Elsevier Academic press.
- Franklin F. Bolander. Molecular Endocrinology. III Edition, Academic Press, USA.

Suggested Readings:

- Hand Book of Physiology published by American Physiological Society by Oxford University Press, Section 7: Multiple volumes set, 1998.
- C. Donnell Turner. General Endocrinology. VI Edition,SaundersToppan.
- Stephen Nussey and Saffron Whitehead (2001). Endocrinology: An Integrated Approach.. BIOS Scientific Publishers (https://www.ncbi.nlm.nih.gov/books/NBK22/)
- Hadley, M.E. and Levine J.E. (2009). Endocrinology.VI Edition. Pearson PrenticeHall, Pearson Education Inc., New Jersey.
- Strauss and Barbieri (2013). Yen & Jaffe's-Reproductive Endocrinology- Physiology, Pathophysiology and Clinical Management. VII Edition, Elsevier

Online Tools and Web Resources:

- https://sites.google.com/site/openmeded/specialties/endocrinology
- https://www.endocrine.org/topics

ZH DSE Course-VII: Fish and Fisheries

Course learning Objective:

Fisheries involve study of both, capturing and culturing of fish. India is a peninsular country with a huge coastline and large inland water bodies. Assisted with such ideal geographical location our nation has outstanding accomplishments in Fish and fisheries. Globally, India is ranked second in Aquaculture and 3rd in Fisheries. In an evolutionary sense, the most successful of the larger aquatic animals are the fishes that are hunted commercially. About 64% of the global marine catch comes from the Pacific Ocean, 28% comes from the Atlantic and 8% from the Indian Ocean. Marine fisheries is a multibillion-dollar industry that is able to fulfil about 20% of the total animal protein requirement of humans, and also produce animal feeds for domestic livestock and poultry, fish oils (for paints and drugs, pet foods) and some food additives. For the increasing human population, there is continuous increase in the demand for high-quality protein. To meet these demands, it is necessary to focus attention on the current stocks from marine as well as freshwater species and create opportunities to increase or at least maintain the amount of harvest. It has become apparent that fisheries management has not always been successful in maintaining fish yields and conserving stocks. This course has been designed to equip the student with a balanced and complete scientific understanding of fisheries concepts.

Course Learning Outcome:

After completion of the course the students will be able to:

- Acquire knowledge of physiology, reproduction of fishes.
- Analyse different kinds of water and identify/differentiate different kinds of fishes.
- Procure pure fish seed by artificial procedures such as artificial and induced breeding which can learn by visiting any fish farm or demonstrated in research labs in college/Departments
- Become aware and gain knowledge of In-land and marine Fisheries in India and how it contributes to Indian economy.
- Know about different kinds of fishing methods and fish preservation which can be employed for export and storage of commercial fishes.
- Find the reasons behind the depletion of fisheries resources.
- Develop skills for entrepreneurship or self-employment in their own fisheries-related business.

Course Content:

Theory [Credits: 2] 60 hrs

Unit 1: Introduction and Classification 6 hrs

General description of fish; Account of systematic classification of fishes (upto classes); Classification based on feeding habit, habitat and manner of reproduction.

(Chapter 1 and 8: Jhingaran; Chapter 18: Norman; Chapter 18: Shrivastava)

Unit 2: Morphology and Physiology 18 hrs

Types of fins and their modifications; Locomotion in fishes; Hydrodynamics; Types of Scales, Gills and gas exchange; Swim Bladder: Types and role in Respiration, buoyancy; Osmoregulation in Elasmobranchs; Reproductive strategies (special reference to Indian fishes); Electric organs; Bioluminiscience; Mechanoreceptors; Schooling; Parental care; Migration

(*Chapter 2, 3, 4, 5, 8, 10, 13, 14 and 15: Norman)*

Unit 3: Fisheries 12 hrs

Inland Fisheries; Marine Fisheries; Environmental factors influencing the seasonal variations in fish catches in the Arabian Sea and the Bay of Bengal; Fishing crafts and Gears; Depletion of fisheries resources; Application of remote sensing and GIS in fisheries; Fisheries law and regulations

(*Chapter 4 and 21: Jhingaran; Chapter 19: Norman; Chapter 3, 13 and 14: Shrivastava)*

Unit 4: Aquaculture 20 hrs

Sustainable Aquaculture; Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Induced breeding of fish; Management of finfish hatcheries; Preparation and maintenance of fish aquarium; Preparation of compound diets for fish; Role of water quality in aquaculture; Fish diseases: Bacterial, viral and parasitic; Preservation and processing of harvested fish, Fishery by-products.

(*Chapter 8, 9, 10, 12, 16, 19 and 20:Jhingaran; Chapter 20: Norman: Chapter 9, 10 and 15: Shrivastava)*

Unit 5:Fish in Research 4 hrs

Transgenic fish, Zebra fish as a model organism in research.

(Chapter 17: Shrivastava)

Practical [Credits: 2]

1. Study of *Petromyzon*, *Myxine*, *Pristis*, *Chimaera, Exocoetus*, *Hippocampus*, *Gambusia, Labeo, Heteropneustes, Anabas* (at least one fishfrom each class).
2. Study of different types of scales (through permanent slides/ photographs).
3. Study of crafts and gears used in Fisheries.
4. Water quality criteria for Aquaculture: Assessment of pH, conductivity, Total solids, Total dissolved solids, dissolved oxygen.
5. Study of air breathing organs in *Channa, Heteropneustes, Anabas* and *Clarias.*
6. Demonstration of induced breeding in Fishes (video/visit to fisheries institute/fish farm)
7. Demonstration of parental care in fishes (video).
8. Different methods of fish tagging.
9. Determination of fish density in a pond by Peterson's mark recapture method.
10. Project Report on a visit to any fish farm/pisciculture unit/Zebrafish rearing Lab.

Teaching and Learning Process:

There would be a teacher-centered lecture sessions, where students can take notes or absorb information and interact with the teacher. The teacher/student-based lessons would be supported by multimedia presentations (videos/animations). Visit to Field, Fisheries institutes, laboratory or Aquatic research institutes would be useful to students for better understanding of the subject.

Assessment Methods:

- Formative assessment to analyze student's performance during instruction on regular basis throughout the instruction process.
- Summative Assessment to measure a student's achievement at the end of instruction.
- Written tests to analyze their intake on taught lectures.

- Inspiringthe students to give talks through power point presentations/submit assignments with emphasis on recent studies in Fish and Fisheries.

Keywords:
Fish Classification, Fish physiology, Reproduction, Fisheries, Aquaculture, Transgenic fish

Recommended Books:
- Srivastava, C.B.L. Fish Biology. Narendra Publishing House.
- Jhingran, V.G. (1982) Fish and Fisheries in India. Hindustan publication Cooperation, India.

Suggested Readings:
- Pandey, K. and Shukla, J.P. (2013) Fish and Fisheries. Rastogi publication, India
- Norman, J.R. A History of Fishes. Hill and Wang Publishers.
- Khanna, S.S. and Singh, H.R. A text book of Fish Biology and Fisheries. Narendra Publishing House.
- Bone,Q. and Moore, R. Biology of Fishes. Talyor and Francis Group, CRC Press, U.K.

ZH DSE Course-VIII: Immunology

Course Learning Objective:

The aim of the course in immunology is to apprise the student with the working of the immune system in normal health and how it fights the disease and may sometimes contributes to disease. The immune system is incredibly complex. This course is hence designed to enable understanding the molecular and cellular basis of the development and function of the immune system and identification of its biological, clinical and therapeutic implications.

Course Learning Outcome:

After completion of the course the students will be able to:

- Describe the basic mechanisms, distinctions and functional interplay of innate and adaptive immunity
- Define the cellular/molecular pathways of humoral/cell-mediated adaptive responses including the role of Major Histocompatibility Complex
- Explain the cellular and molecular aspects of lymphocyte activation, homeostasis, differentiation, and memory
- Understand the molecular basis of complex, humoral (Cytokines and Complement)and cellular processes involved in inflammation and immunity, in states of health and disease
- Describe basic and state-of-the-art experimental methods and technologies
- Integrate knowledge of each subsystem to see their contribution to the functioning of higher-level systems in health and disease including basis of vaccination, autoimmunity, immunodeficiency, hypersensitivity and tolerance

Course Content:

Theory [Credits: 4] 60 hrs

Unit1: Overview of Immune System 10 hrs

Historical perspective of Immunology, Early theories of Immunology, Clonal Selection Theory, Cardinal features of vertebrate immune system, Hematopoiesis, Cells and organs of the Immune system.

(Chapter 1, 2: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit2: Innate and Adaptive Immunity 10 hrs

Anatomical barriers, Inflammation, Cell and molecules involved in innate Immunity, Adaptive Immunity (Cell-mediated and Humoral), Passive immunity; Active: Artificial and natural Immunity, Immunological Tolerance

(Chapter 1, 3 and 16: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit 3: Antigens 8 hrs

Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes

(Chapter 4: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit4: Immunoglobulins 10 hrs

Structure and functions of different classes of immunoglobulins, Antigenic determinants on Immunoglobulins, Antigen-antibody interactions (Precipitation reactions, Agglutination reactions, Immunofluorescence and ELISA), Polyclonal sera, Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis

(Chapter 4 and 6: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit 5: Major Histocompatibility Complex 4 hrs

Structure and functions of MHC molecules (MHC I and II), Endogenous and exogenous pathways of antigen processing and presentation

(Chapter 8: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit6: Cytokines 3 hrs

Properties and functions of cytokines

(Chapter 12: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit7: Complement System 4 hrs

Components and pathways of complement activation, Biological consequences of complement activation

(Chapter 7: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit8: Vaccines 4 hrs

Various types of vaccines

(Chapter 19: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Unit9: Immune Dysfunction 7 hrs

Hypersensitivity: Gell and Coombs' classification and various types of hypersensitivities Autoimmunity: Brief account with reference to Hashimoto's Thyroiditis (Organ Specific) and Rheumatoid arthritis (Systemic).Immunodeficiency: Brief account with reference to SCID (Primary) and AIDS (Secondary)

(Chapter 9: Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J.)

Practical [Credits 2]

1. Demonstration of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/photographs.
3. Preparation of stained blood film to study various types of blood cells.
4. Basic patterns of precipitation by Ouchterlony's double immuno-diffusion method.
5. ABO Blood group antigen determination by heamagglutination.
6. Cell counting and viability test from splenocytes of farm bred animals/cell lines.
7. Demonstration of:
   (a) ELISA
   (b) Immunoelectrophoresis
8. Detection of complement activity using haemolysis of antibody coated SRBC and standard serum

Teaching and Learning Process:

The course on immunology has been structured to develop the requisite knowledge, skills and learning attitude of the student. The process is extremely student-oriented and includes details of cells and organs of the system, antigens, antibodies, autoimmunity, immunodeficiency, hypersensitivity and other important aspects. The practical exercises are accordingly designed to enhance the interest of the students.A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, problem-based learning, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this.

Problem-based learning skills and higher-order skills of reasoning and analysis will be encouraged through research based pedagogical tools. The students must be given sufficient support by faculty to apply their learning and acquire knowledge from real life situations.

Assessment Methods:

The assessment of students' achievement in immunology will be aligned with the course/program learning outcomes.

- Continuous evaluation of learning by formative and diagnostic evaluation should be followed at the University.
- Efforts should be made to measure cognitive as well as applied learning.
- Project work, quiz, problem solving exercise, classroom assessment methods, closed-book and open-book tests, problem-solving exercises, practical assignment, laboratory reports, seminar presentation, *viva-voce,* interviews, computerized adaptive testing, literature surveys and summative evaluations by end-semester examination etc. constitute the different components of the overall assessment.
- Moreover, students should be provided with feedback on their work with the aim of improving their academic performance.

Keywords:

Adaptive Immunity, Innate Immunity, cytokines, complement, hypersensitivity, autoimmunity, immunodeficiency, Vaccines

RecommendedBooks:

- Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006). Immunology, VIEdition, W.H. Freeman and Company.
- David, M., Jonathan, B., David, R. B. and Ivan, R. (2006). Immunology, VII Edition, Mosby, Elsevier Publication.

Suggested Readings:

- Abbas, K. Abul and Lechtman H. Andrew (2003) Cellular and Molecular Immunology.V Edition, Saunders Publication.
- Kenneth Murphy and Casey Weaver. Janeway's Immunobiology, IX Edition, Garland Science

Online Tools and Web Resources:

- E-content on e-PG Pathshala portal of Government of India: https://epgp.inflibnet.ac.inFundamentals of Immunology;https://www.coursera.org/specializations/immunology

ZH DSE Course-IX: Parasitology

Course Learning Objective:

Parasites are vast menagerie. They can cause diseases without pardon. They can slip into a person's brain wrecking the biological clock turning the day into nights. They can cause livers of cattle useless and roots of plants functionless. They may cause a tourist spot an epicenter of epidemic disease. There is an enormous diversity of parasites in nature and knowing and understanding them well becomes very important in the light of controlling and managing the parasites effectively. The economic impact of these organisms is often huge and that makes it even more important to study them. Parasitology will enable us diagnose parasites correctly, understand their life cycle and control them effectively and use some of them as bio control agents.Parasitology; especially the study of life cycles of parasites;has helped in defying the stigmas and religious taboos for many societies making free many of the people from superstition and ill health. Developing countries like our country where majority of the people are engaged in agricultural activities and living in poor conditions have advantages to be harvested from the study of parasitology. The course shall surely skill the students to see, appreciate and understand the diversities of parasites in the whole spectrum of the study of life. The course shall also make the students aware about the possible scopes of the subject which include research and applied aspects including entrepreneurial works.

Course Learning Outcome:

After completion of the course the students will be able to:

- Understand the variation amongst parasites, parasitic invasion in both plants and animals;applicable to medical and agriculture aspects.
- Help to know the stages of the life cycles of the parasites and the respective infective stages.
- Develop ecological model, knowpopulation dynamics of parasite, establishment of parasite population in host body, adaptive radiations and methods adopted by parasite to combat with the host immune system
- Develop skills and realize significance of diagnosis of parasitic attackand treatment of patient or host.
- Learn important case studies to highlight interesting researches, serendipities towards the advancement and enrichment of knowledge in the field of Parasitology.

Course Content:

Theory [Credits: 4] 60 hrs

<u>Unit</u>1: Introduction to Parasitology 5 hrs

Brief introduction of Parasitism, Parasite, Parasitoid and Vectors (mechanical and biological vector) Host parasite relationship, Ecology of parasites, Population dynamics of parasite and establishment of parasite population in host body, evolution of parasitism, evolution and co-evolution of parasite with respect to host strategy, Important case studies in the field of Parasitology including some historical events such as the role of the mosquito control and the successful completion of the construction of the Panama canal.

(Chapter 1: E.R. Noble and G.A. Noble; Community Ecology Section: Smith; Introduction Section: Baker; Introduction Section: Zimmer; Division V: General Discussion: Mala Bose)

Unit2: Parasitic Protists 14 hrs

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Entamoeba histolytica, Giardiaintestinalis, Trypanosoma gambiense, Leishmaniadonovani, Plasmodium vivax.*
(*Chapter 1, 2, 3, 4 and 5:K. D. Chatterjee; Chapter 1: Arora and Arora; Section I and II: Parija; Ichhpujani & Bhatia.*

Unit3: Parasitic Platyhelminthes 14 hrs

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Fasciolopsis buski, Schistosomahaematobium, Taenia solium* and *Hymenolepis nana.*
(Chapter 6 and 7: K. D. Chatterjee; Chapters 8-11: Arora and Arora; Parija.; Ichhpujani& Bhatia)

Unit4: Parasitic Nematodes 15hrs

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Ascaris lumbricoides*, *Ancylostomaduodenale*, *Wuchereriabancrofti* and *Trichinella spiralis.* Study of structure, lifecycle and importance of *Meloidogyne* (Root knot nematode), *Pratylencus* (Lesionnematode)
(Chapter 8: K. D. Chatterjee; Chapter 11 and 12: Arora and Arora; Parija; Ichhpujani& Bhatia)

Unit5: Parasitic Arthropoda 10hrs

Biology, importance and control of ticks, mites, *Pediculus humanus* (Head andBody louse), *Xenopsylla cheopis* and *Cimex lectularius*
(Cheng; Heinz Mehlhorn, 2012 Arthropods as vectors of merging Diseases. In Parasitology Research Monographs, Vol. 3, p. 397)

Unit6: Parasitic Vertebrates 2hrs

A brief account of parasitic vertebrates; Cookicutter Shark, Candiru, HoodMockingbird and Vampire bat.
(Klimpel & Mehlhorn; Gudger)

Practical [Credits: 2]

1. Study of life stages of *Entamoeba histolytica*, *Giardia intestinalis, Trypanosoma gambiense, Leishmania donovani* and *Plasmodium vivax*through permanentslides/micro photographs.
2. Study of adult and life stages of *Fasciolopsis buski, Schistosomahaematobium, Taenia solium* and *Hymenolepis nana* through permanentslides/microphotographs.
3. Study of adult and life stages of *Ascaris lumbricoides, Ancylostomaduodenale, Wuchereria bancrofti* and *Trichinella spiralis* throughpermanent slides/microphotographs.
4. Study of plant parasitic root knot nematode, *Meloidogyne* from the soilsample.
5. Study of *Pediculus humanus* (Head louse and Body louse), *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs.
6. Study of monogenea from the gills of fresh/marine fish [Gills can beprocured from fish market as by product of the industry]

7. Study of nematode/cestode parasites from the intestines of Poultry bird [Intestine can be procured from poultry/market as by product]
8. Submission of a brief report on parasitic vertebrates.
9. Visit to rural area/hospital near rural area/NCDC/NMIR/NICD to study natural history of parasites.
10. Parasite album, photograph collection: Tissue invasion, Life cycle
11. Culturing root parasites in laboratory, field
12. DNA extraction of parasite/s and molecular identification using universal and specific markers

Teaching and Learning Process:

Classroom teaching using power point presentations enabled with related photographs of parasites their life stages and disease diagnosis will help students to understand the subject.Case studies of epidemics caused by different parasites will clarify concept and create interest in the field.Visit to local diagnostic centre will provide an overview of various medical tests conducted to detect and confirm parasitic diseases.

Assessment Methods:

The learners/ students can be assessed in many different ways.

- Formative feedback throughout the course and summative feedback as mid-semester and semester-end evaluation.
- Presenting the topics in the class *via* blackboard teaching/presentations, group discussions etc.
- Students would be provided feedback on their work with a view to improve their academic performance.
- From time to time, learners will be given practical problems and neuroimages to test their theoretical skills and promote practical knowledge.
- They would be provided feedback on their work with a view to improve their academic performance.
- Discipline assessed through regularity and behaviour

Keywords:

Host, Parasites, Diseases, Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis, Treatment

Recommended Books:

- Arora, D. R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications and Distributors
- Noble, E.R. and Noble, G.A. (1982) Parasitology: The Biology of Animal Parasites. V Edition, Lea & Febiger

Suggested Readings:

- Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor and Francis Group
- Parija, S. C. Textbook of Medical Parasitology, Protozoology & Helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi

- Ichhpujani, R.L. and Bhatia, R. Medical Parasitology. III Edition, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi
- Murray, D. Dailey. Meyer, Olsen & Schmidt's Essentials of ParasitologyW.C. Brown Publishers
- Thomas C. Cheng (1986). General Parasitology. II Edition, Academic Press Inc
- Chatterjee, K. D. (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBS Publishers & Distributors (P) Ltd.

ZH DSE Course-X: Reproductive Biology

Course Learning Objective:

This course is meant for making the students learn about the various aspects of reproduction in humans. It includes a detailed study of the male and female reproductive systems as well as factors that are important in maintaining reproductive health. The students are also made aware of new technologies in assisted reproduction as well as contraceptive methods. They are taught about social and public health issues related to family planning.

Course Learning Outcome:

After completion of the course the students will be able to:

- Get in-depth understanding of morphology, anatomy and histology of male and female reproductive organs.
- Know different processes in reproduction starting from germ cell formation to fertilization and consequent pregnancy, parturition and lactation.
- Compare estrous and menstrual cycles and their hormonal regulation.
- Comprehend the interplay of various hormones in the functioning and regulation of the male and female reproductive systems.
- Know about the diagnosis and management of infertility, including latest methods, technologies and infrastructure in assisted reproduction.
- Practically understand the modern methods in contraception and their use in family planning strategies.
- Translate their understanding intodevelopment of products like non-hormonal contraceptives; contribute to drug discovery programmes as well as neonatal and maternal health programmes andwork with family planning teams to understand the needs and preferences of individuals belonging to lower socioeconomic groups.

Course Content:

Theory [Credits 4] 60 hrs

<u>Unit</u>1: Reproductive Endocrinology 12 hrs

Hypothalamo–hypophyseal–gonadal axis. Regulation of gonadotropins and gonadal steroids secretion in male and female;Steroidogenesis;Puberty; Mechanism of action of hormones related to reproduction.

(Chapters1, 2, 4 and 6: Jones, R.E. and Lopez, K.H.; Chapters 1, 2, 3, 4, 5, 6 and 7: Johnson, M.H. and Everitt, B.J.)

<u>Unit</u>2: Male Reproductive System 10 hrs

Functional histology and anatomy of male reproductive system: Testis, epididymis, vas deferens, prostate gland, seminal vesicle;Spermatogenesis and its regulation; Sperm transport and maturation in male genital tract

(Chapter 4: Jones, R.E. and Lopez, K.H.; Chapters 3 and 8: Johnson, M.H. and Everitt, B.J.)

<u>Unit</u> 3: Female Reproductive System 28 hrs

Functional histology and anatomy of female reproductive system:Ovary, fallopian tubes/oviducts, uterus, cervix and vagina; Folliculogenesis; Oocyte maturation and ovulation; Corpus luteum formation and regression; Reproductive cycles (estrous and menstrual) and their regulation; changes in the female tract during these cycles.Fertilization; Implantation;

Maternal recognition of pregnancy; Feto-placentalunit; Hormonal regulation of gestation; gestational adaptations; Parturition and its hormonal regulation; Lactation and its regulation *(Chapters 2, 3, 9, 10, 11, and 12: Jones, R.E. and Lopez, K.H.; Chapters 4, 8-13: Johnson, M.H. and Everitt, B.J.*)

Unit4: Reproductive Health and Family Planning 10 hrs

Contraceptive methods;Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technologies: sperm banks, frozen embryos, IVF, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST.

(Chapters 14 and 16: Jones, R.E. and Lopez, K.H.; Chapter 14: Johnson, M.H. and Everitt, B.J.)

Practical [Credits: 2]

1. Study of animal house: Set up and maintenance of animal house, breeding techniques, care of normal and experimental animals.
2. Examination of vaginal smear of rats (from live animals).
3. Surgical techniques: principles of surgery in endocrinology. Ovariectomy, hysterectomy, castration and vasectomy in rats.
4. Examination of histological sections from photomicrographs/permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems; Sections of ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina.
5. Human vaginal exfoliate cytology through micrographs.
6. Sperm count and sperm motility in rat.
7. Study the effect of cryptorchidism on sperm count and motility in rats.
8. Study of modern contraceptive devices.
9. Mini projects involving survey, data collection, statistical analysis and submission of a project report on reproductive health of a small human community

*All exercises requiring live animals are, at present, being performed with the help of photomicrographs/pictures.

Teaching and Learning Process:

Lecture-based learning; aided with diagrams, flow charts and models; will be interactive with simple questions for students to learn and derive logically and think analytically. Examples, wherever possible, will be given from day-to-day activities to explain the concept and make the basics clear, relevant and interesting. After every lecture students will be posed with questions to help them summarise the topic.Regular practical classes will be held to develop the practical skills of students. The topics for practical will include detailed explanations of organ systems using hands-on and digital means. Histological slides will be shown to explain the microscopic structure of various tissues. The students will be assessed on their performance after each practical class.Seminar-based learning will include by delivering seminar by students followed by a discussion to assess their understanding and grasp of the topics.Students will undertake projects for certain topics to sharpen their understanding, enhance critical thinking, reasoning and analysis, and hone their presentation skills.Students will attend in-college workshops on topics related to their study. Experts in the field will be invited to hold workshops. Students will also be taken on field trips to subject related locations/agencies for a practical understanding of skills required for their potential future workplace.Mock practical/theory examinations will be held before the university examination. The pattern of questions would match the university question paper to better equip the students to perform with confidence in the final examination.

Assessment Methods:

Students of the reproductive biology study programme will be assessed on the basis of their course learning outcomes as well as relevant skills. A variety of assessment methods will be used:

- Time-constrained oral and written examinations
- Problem-based assignments, individual project reports
- Practical file reports
- *Viva-voce* and
- Class assessments *via* observation of practical skills and regular class tests.

Keywords:

Reproductive system, Puberty, Spermatogenesis, Oogenesis, Folliculogenesis, Menstrual cycle, Estrous cycle, Infertility, Pregnancy, Family planning, Reproductive health

RecommendedBooks:

- Jones, R.E. and Lopez, K.H. (2014) Human Reproductive Biology.IV Edition, Elsevier.
- Johnson, M.H. and Everitt, B.J. (1995) Essential reproduction. IVEdition, London, Blackwell Science (Eighth edition by Johnson, MH., 2018)

Suggested Readings:

- Austin, C.R. and Short R.V. (Eds) (2012). Reproduction in Mammals. Cambridge University Press. (online edition)
- De-Groot, L.J. and Jameson, J.L. (eds) (2001). Endocrinology. W.B. Saunders and Company.
- Franklyn F. Bolander (2012). Molecular Endocrinology. III Edition, USA, Academic Press.
- Knobil, E. and Neil, JD (eds.) (2014). The Physiology of Reproduction. IV Edition, Elsevier.
- Hatcher, R.A. et al. (1997). The Essentials of Contraceptive Technology. Population Information Programme. John Hopkins School of Public Health.
- Robert Martin (2013). How We Do It: The Evolution and Future of Human Reproduction. Basic Books.
- Peter T. Ellison (2001). On Fertile Ground: A Natural History of Human Reproduction. Harvard University Press.

Online Tools and Web Resources:

- Introduction to reproduction: https://www.classcentral.com/course/coursera-introduction-to-reproduction-4252
- Anatomy & Physiology: Sexual Reproduction in Humans: https://www.classcentral.com/tag/reproductive-health?subject=health

ZH DSE Course-XI: Wildlife Conservation and Management

Course Learning Objective:

The Discipline Specific Paper on Wildlife Conservation and Management is designed to acquaint students with varied aspects of wildlife conservation, including its importance, major threats, management of their habitats and populations. The emphasis will be on developing interest and invoking a sense of responsibility among students towards wildlife conservation. The course also explores different techniques, perspectives, and approaches to both identify and achieve wildlife management goals. This course will motivate students to pursue career in the field of wildlife conservation and management.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Become aware about the importance of wildlife in general, and its conservation and management in particular.
- Comprehend the application of the principles of ecology and animal behaviour to formulate strategies for the management of wildlife populations and their habitats.
- Understand the management practices required to achieve a healthy ecosystem for wildlife population along with emphasis on conservation and restoration.
- Knowthe key factors for loss of wildlife and important strategies for their *in situ* and *ex situ* conservation.
- Recognize the techniques for estimation, remote sensing and Global Position Tracking for wildlife.
- Gain knowledge about the wildlife diseases and the quarantine policies.
- Know about the Protected Area Networks in India, Ecotourism, Ecology of perturbation and Climax persistence.
- Perform critical thinking, literature review; scientific writing as well as presentations; and participation in citizen science initiatives with reference to wildlife.

Course Content:
Theory [Credits: 4] 60hrs

Unit 1: Introduction to Wildlife 6hrs

Values of wildlife - positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies: WCS, CBD, Agenda 21

(Chapter 1, 2, 3 and 10: Singh; Chapter 1 and 3: Saha and Mazumdar)

Unit 2: Evaluation and Management of Wildlife 10hrs

Habitat analysis: a) Physical parameters: Topography, Geology, Soil and water; b) Biological Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS.

(Chapter 2, 11 & 12: Sutherland; Chapter 6: Singh; Chapter 6: Saha and Mazumdar)

Unit 3: Management of Habitats 10hrs

Setting back succession: Grazing logging; Mechanical treatment; Advancing the successional process: Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats.

(Chapter 11 & 12: Sutherland; Chapter 6: Singh)

Unit4: Population Estimation 12 hrs

Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, and Hair identification; Pug marks and Census methods

(Chapter 2 & 4: Sutherland; Chapter 8 and 9: Singh; Chapter 6: Saha and Mazumdar)

Unit5: Management Planning of Wildlife in Protected Areas 8hrs

Estimation of carrying capacity; Human-wildlife conflict; Eco tourism / wild life tourism in forests; Climax communities: characteristics and theories; Ecology of purterbance.

(Chapter 9: Sutherland; Chapter 1: Woodroff; Chapters 8 and 11: Singh; Chapter 9: Saha and Mazumdar)

Unit6: Management of Excess Population 6hrs

Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animals: Zoonosis (Ebola and Salmonellosis), Rabies, Foot and Mouth Disease, *Mycobacterium* TB, Bovine and Avian Flu

(Chapters 6, 7 and 11: Saha and Mazumdar)

Unit:7 Protected Areas 8hrs

National parks and sanctuaries; Biosphere reserves; Conservation and Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India and Management challenges in Tiger reserve

(Chapters 11 and 12: Singh; Chapters 3 and 9: Saha and Mazumdar)

Practical [Credits: 2]

1. Identification of mammalian fauna, avian fauna, herpeto-fauna through direct and indirect evidences seen on a field trip to a wildlife conservation site.
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System,Various types of Cameras and lenses).
3. Familiarization and study of animal evidences in the field: Identification of animals through pug marks, hoof marks, scats, nests and antlers.
4. Demonstration of different field techniques for flora and fauna: PCQM.
5. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).
6. Identification of big cats: Lion, tiger, panther, cheetah, leopard and jaguar.
7. A report based on a visit to National Park/Wildlife Sanctuary/Biodiversity Park or any other wildlife conservation site.

Teaching and Learning Process:

The case study approach with real-life examples from the field will give a better understanding of the subject and its applications.The traditional chalk and talk method will be supplemented with LCD projection system and use of visualizer for theory classes. Projection of videos or short movies available on the subject will enhance the understanding of the subject. Digital collection of pictures of pugmarks, hoof marks, bird's nests, wild fauna and flora will facilitate observation of their characteristic features with ease.Group discussions, book reviews, paper presentations, videos, animations, are some methods that can be employed for effective teaching. Project based reports, assignments and E-posters can also form an important part of learning regime.Field-based research projects will develop interest in the subject and motivate students to peruse research as a career in future.Laboratory visits to renowned institutions like WII, Dehradun and Field visits to various conservation sites like Jim Corbett National Park, Aravali Biodiversity Park and National Zoological Park will provide students a practical or hands on knowledge of the subject.Students should participate in citizen science initiatives related to wildlife such as bird counts and uploading of the data on E-bird.org.

Assessment Methods:

Students will be assessed using the following methods:

- Formative/ Continuous assessment: This will be done through problem solving exercises, oral and written examinations, closed-book and open book tests, practical assignment laboratory reports, observation of practical skills, individual project reports, seminar presentation, viva voce interviews, computerized adaptive testing, literature surveys and evaluations, outputs from collaborative work etc. to assess the retention abilities of students.
- Summative assessment: Semester-end written and practical examinations will be an indicator of student's learning throughout the semester and analyses comprehensive knowledge gained by the students.

Keywords:

Wildlife, Conservation, Management, Population, Habitat, Succession, Climax, Quarantine, Tiger Project, National Park, Wildlife Sanctuaries, Biodiversity Reserves, Wildlife Diseases, Protected Areas

Recommended Books:

- Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHI learning Pvt. Ltd. ISBN: 8120353137, 978-812035313
- Sinclair, A.R.E., Fryxell, J.M. and Caughley,G. (2006). Wildlife Ecology, Conservation and Management. Wiley-Blackwell, Oxford, UK.
- Singh, S.K. (2005). Text Book of Wildlife Management. IBDC, Lucknow.

Suggested Readings:

- Hudson, P.J., Rizzoli, A., Grenfell, B.T. Heestrbeek, H. and Dobson, A.P. (2002). The Ecology of Wildlife Diseases. Oxford University Press, Oxford.
- Banerjee, K. (2002). Biodiversity Conservation in Managed and Protected Areas. Agrobios, India.
- Sharma, B.D. (1999). Indian Wildlife Resources Ecologyand Development. Daya Publishing House, Delhi.
- Primack, R.B. (1998). Essentials of Conservation Biology. Sinauer Associates, Inc. Sunderland, MA.
- Hossetti, B. B. (1997). Concepts in Wildlife Management. Daya Publishing House, Delhi.

Online Tools and Web Resources:

- https://swayam.gov.in/courses/4687-july-2018-wildlife-conservation
- https://swayam.gov.in/courses/5364-jan-2019-wild-life-ecology
- https://papaco.org/mooc-on-species-conservation/
- https://www.iucn.org/theme/protected-areas/our-work/capacity-development/moocs
- https://www.zsl.org/united-for-wildlife-free-conservation-courses
- https://wildlife.org/next-generation/career-development/online-courses/
- https://www.openlearning.com/umtmooc/courses/wildlife-management

ZH GE-I: Animal Cell Biotechnology

Course Learning Objective:

The syllabus of Generic elective course/ paper on "Animal Cell Biotechnology" is revised to cater to the needs of Choice Based Credit System (CBCS). The changing scenario of higher education in India and abroad is taken into consideration to make this syllabus more oriented towards current need of modern research and industrial sectors. The revised and updated syllabus is based on a basic and applied approach with vigor and depth. Empowerment of students to face research and industrial outlets by nurturing independent thinking, initiating scientific enquiry and developing their entrepreneurship skills is at the centre of this syllabus. The units of the syllabus are well defined, taking into consideration the level and capacity of students.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Get a clear concept of the basic principles and applications of biotechnology.
- Know the basic techniques used in genetic manipulation helping them continue with higher studies in this field.
- Acquire knowledge of the basic principles, preparations and handling required for animal cell culture.
- Understand principles underlying the design of fermenter and fermentation process and its immense use in the industry.
- Design small experiments for successful implementation of the ideas and develop solutions to solve problems related to biotechnology keeping in mind safety factor for environment and society.
- Apply knowledge and skills gained in the course to develop new diagnostic kits and to innovate new technologies further in their career.
- Enhance their understanding of the various aspects and applications of biotechnology as well as the importance of bio-safety and ethical issues related to it.

Course Content:

Theory [Credits: 4] 60 hrs

Unit1: Introduction 2 hrs

Concept and Scope of Biotechnology

(Chapter 1: Glick)

Unit2: Techniques in Gene Manipulation 20hrs

Outline process of genetic engineering and recombinant DNA technology, Isolation of genes, Concept of restriction and modification: Restriction endonucleases, DNA modifying enzymes, Cloning Vectors: Plasmids, Phage vectors, Cosmids, Phagemids (lambda & M13), BAC, YAC, HAC. Shuttle and Expression Vectors. Construction and screening of Genomic libraries and cDNA libraries. Transformation techniques: Electroporation and Calcium Chloride method.Agarose and Polyacrylamide Gel Electrophoresis, Southern, Northern and Western blotting, DNA sequencing: Sanger method, Polymerase chain reaction, DNA Fingerprinting and DNA microarrays.

(Chapter 3, 4, 5 and 9: Glick; Chapter 4: Watson)

Unit 3: Fermentation 15hrs

Different types of Fermentation: Submerged & Solid state; batch, Fed batch & Continuous; Stirred tank, Air Lift, Downstream Processing: Filtration, centrifugation, extraction, chromatography (Only Principles: Adsorption, Ion exchange, gel filtration, hydrophobic, affinity and size exclusion and lyophilization.
(Chapter 17: Glick; Chapter 14: Singh)

Unit 4: Transgenic Animal Technology 5 hrs
Production of transgenic animals: Retroviral method, DNA microinjection method, Nuclear Transplantation: Dolly and Polly.
(Chapter 21: Glick)

Unit 5: Animal Cell Culture and rDNA Application in Health 18 hrs
Basic techniques in animal cell culture, Primary Culture and Cell lines, Culture media-Natural and Synthetic, Cryopreservation of cultures, Recombinant Vaccines, Gene Therapy (*in-vivo* and *ex-vivo*), Production of recombinant Proteins: Monoclonal Antibodies, Insulin and growth hormones, Bio safety: Physical and Biological containment.
(Chapter 10 and 11 Glick; Chapter 5 and 20: Singh)

Practical [Credits: 2]

1. Packing and sterilization of glass and plastic wares for cell culture.
2. Preparation and sterilization of culture media.
3. Preparation of genomic DNA from *E. coli*.
4. Plasmid DNA isolation (pUC 18/19) and its detection on agarose gel.
5. Calculation of transformation efficiency from the data provided
6. Restriction digestion of lambda (λ) DNA using *Eco*R1 and *Hind* III.
7. Techniques:
    a) Western Blot
    b) Southern Hybridization
    c) DNA Fingerprinting
    d) PCR
    e) DNA Microarrays

Teaching and Learning Process:

As the students of Generic Elective papers are from different and unrelated discipline (s) the revised syllabus is framed with a basic introduction to the concept of genetic engineering, scientific techniques and applications. Effective teaching involves aligning the three major components of instruction: learning objectives, assessments, and instructional activities. To increase the participation of students and in turn develop their interest in the topic; more discussions/ Quizzes will be included.Brain storming sessions will be held to help students march towards scientific excellence, the recent research activities/trends.Open Learning Resourceslike SWAYAM, MOOC etc. will be shown.Field trips/visits to Institute/Industry will be plannedto provide better exposure and more practical view of studying science and applying it judiciously. Students understanding will be assessed at frequent intervals throughout the learning process. Continuous evaluation of learning will be carried out and efforts will be made to measure cognitive as well as applied learning. Project work, quiz, problem solving exercise, classroom assessment methods, end-semester examination, etc. will constitute the different components of the overall assessment. Extra efforts and time slots will be given to students facing difficulty in understanding any topic/concept etc.

Assessment Methods:

- Regular class tests with objective/subjective questions.
- Oral presentation on regular basis by students.
- Group discussion: Dividing the class into groups and assign each group a topic or latest
- development/scientific finding in the field of biotechnology.
- Small projects can be designed by students (a group of 3 students) to enhance their critical thinking, improving scientific writing and honing their skills.
- Assignment work.

Keywords:

Restriction enzymes, Vector, Transformation, Fermentation, Transgenic, Gene Therapy

Recommended Books:

- Mathur, J.P. and Barnes, D. (1998). Methods in Cell Biology:. Animal Cell Culture Methods. Academic Press
- Brown, T.A. (1998). Molecular Biology Labfax II: Gene Cloning and DNA Analysis. II Edition, Academic Press, California, USA.
- Glick, B.R. and Pasternak, J.J. (2009). Molecular Biotechnology- Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.

Suggested Readings:

- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C.and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA.
- Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA-Genes and Genomes-A Short Course. III Edition, Freeman and Co., N.Y., USA.

Online Tools and Web Resources:

- https://epgp.inflibnet.ac.in/
- https://swayam.gov.in/Home

ZH GE-II: Animal Diversity

Course Learning Objective:

Zoology is the scientific study of animal life. Animals are the most diverse creatures on this planet. This course gives a framework for understandingthe diversity within different groups, and interrelationship among different species and genera within each group. The aim of this course is to understand the importance of animal kingdom in context to hierarchy, body plan and their role in ecological development. This course provides an overview of the invertebrate and vertebrate animals, including sponges, cnidarians, flatworms, nematodes, annelids, molluscs, arthropods, echinoderms, invertebrate chordates, fishes, amphibians, reptiles, birds, and mammals. This paper comprises of 15 units. First nine units provide knowledge of coelom formation, different level of organization, different modes of living, evolutionary changes of Non-chordates and their salient features. Whereas, remaining units will impart knowledge on different classes of chordates. After completion of this course, the learners will have a framework for understanding all of the different types of animals, and the characteristics of each.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Distinguish between major phyla of animals through a demonstrated understanding of their taxonomic classification and diversity.
- Describe the distinguishing characteristics of all major phyla.
- Understand the fundamental differences among animal body plans and relate them to function, taxonomic classification, and evolutionary relationships among phyla.
- Illustrate lifecycles, structure, function and reasons for importance of few representative organisms from different groups of animals.
- Identify anatomical structures from prepared tissues.
- Observe living animals in the environment and relate observations to theory from the course.
- Recognize major animal phyla and animals on the basis of their external characteristics.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Protista 4 hrs

General characters of Protozoa; Life cycle of *Plasmodium*

(Chapter 3: Ruppert, Fox & Barnes; Chapter 28: Campbell & Reece)

Unit 2: Porifera 4 hrs

General characters and canal system in Porifera

(Chapter 5: Ruppert, Fox &Barnes)

Unit 3: Radiata 3 hrs

General characters of Cnidarians and polymorphism

(Chapter 7: Ruppert, Fox &Barnes)

Unit 4: Aceolomates 3 hrs

General characters of Helminthes; Life cycle of *Taenia solium*
(Chapter 10: Ruppert, Fox & Barnes)

Unit 5: Pseudocoelomates 3 hrs
General characters of Nemathelminthes; Parasitic adaptations.
(Chapter 11: Barnes)

Unit 6: Coelomate Protostomes 3 hrs
General characters of Annelida; Metamerism.
(Chapter 13: Ruppert, Fox & Barnes; Chapter 33: Campbell & Reece)

Unit 7: Arthropoda 5hrs
General characters; Social life in insects.
(Chapter 16: Ruppert, Fox & Barnes; Chapter 46: Raven)

Unit 8: Mollusca 4hrs
General characters of mollusca; Pearl Formation.
(Chapter 12: Ruppert, Fox & Barnes)

Unit 9: Coelomate Deuterostomes 5 hrs
General characters of Echinodermata, Water Vascular system in Starfish.
(Chapter 28: Ruppert, Fox & Barnes; Chapter 47: Raven)

Unit 10: Protochordata 3hrs
Salient features of protochordata
(Chapter 2 and 3: Young)

Unit 11: Pisces 5hrs
General characters of Pisces, Osmoregulation in Fishes.
(Chapter5: Young; Chapter 14: Kardong)

Unit 12: Amphibia 5hrs
General characters, Adaptations for terrestrial life, Parental care in Amphibia.
(Chapter12: Young)

Unit 13: Reptilia 4hrs
General characters, Terrestrial adaptations inreptiles, Poisonous and Non-poisonous snakes
(Chapter34: Campbell & Reece; Chapter14, Young)

Unit 14: Aves 4hrs
General Characters, Flight adaptations.
(Chapter34: Campbell & Reece; Chapter 15 and 17: Young)

Unit 15: Mammalia 5hrs
General Characters; Primates; Dentition in mammals
(Chapter: 22 and 24: Young)

Practical [Credits: 2]

1. Study of specimens:

- Non-chordates**:** *Euglena, Noctiluca, Paramecium, Sycon,Physalia, Tubipora, Metridium, Taenia, Ascaris, Nereis, Aphrodite, Leech, Peripatus, Limulus,* Hermitcrab*, Daphnia,* Millipede, Centipede, Beetle*, Chiton, Dentalium, Octopus, Asterias and Antedon.*
- Chordates*: Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Icthyophis/Uraeotyphlus, Salamandra, Rhacophorus Draco, Uromastix, Naja, Viper,* Model of *Archaeopteryx,* Any three common birds- (Crow, duck, Owl), Squirrel and Bat.

2. Study of Permanent Slides:
   - Cross section of *Sycon*, Sea anemone and *Ascaris (*male and female*).*
   - T. S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine.
   - Bipinnaria and Pluteus larva.
3. Study of:
   - Septal & pharyngeal nephridia of earthworm.
   - Placoid, Cycloid and ctenoid scales.
4. Study of following organ systems:
   - Digestive System of Cockroach.
   - Urinogenital system of Rat

Teaching and Learning Process:

Teaching-Learning process will include delivery of lectures using boards, Multimedia presentation, short documentaries on animal diversity, imparting practical based knowledge through specimens, live demonstration of diversity in surroundings.

Assessment Methods:

Assessment methods are:

- Course examination
- Multiple choice questions quiz at the end of each lecture
- Case studies
- Oral presentation by students
- Report or essay writing
- Project based to assess the skills of scientific enquiry and problem-solving

Keywords:

Invertebrates, Vertebrates, Protozoa, Parazoa, Metazoa, Protochordates, Parasitic adaptations, Migration, Parental care, Biting mechanism, Osmoregulation, Canal system, Water vascular system

Recommended Books:

- Campbell and Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
- Raven, P. H. and Johnson, G. B. (2004). Biology, VIEdition, Tata McGraw Hill Publications. New Delhi.

Suggested Readings:

- Barnes, R.D. (1992). Invertebrate Zoology. Saunders College Pub. USA.
- Ruppert, Fox and Barnes (2006). Invertebrate Zoology. A functional Evolutionary Approach,VII Edition, Thomson Books/Cole
- Kardong, K. V. (2002). Vertebrates Comparative Anatomy. Function and Evolution. Tata McGraw Hill Publishing Company. New Delhi.

. **Online Tools and Web Resources:**

- http://vle.du.ac.in
- Animal Diversity Web (ADW); an online database of animal natural history, distribution, classification, and conservation biology. Web resource https://animaldiversity.org/
- Online Zoo;https://www.activewild.com/online-zoo/

ZH GE-III: Aquatic Biology

Course Learning Objective:

Aquatic biology is a scientific discipline that investigates study of all life forms like plants, animals and chemicals prevalent in the waters from different sources such as lakes, rivers, streams, wetlands, marine environments etc. It is a modern area of academic study and research-oriented program. This program helps students to study about aquatic life and equip students with skills that can later lead into a profession in aquatic biology. Aquatic biology at undergraduate level works as an entry point for future aquatic biologist. Two major aspects of Aquatic biology are study of the organisms in the freshwater (Limnology) and saline waters (Marine biology). This paper focuses on research and explains processes, structures and pathways in most aquatic and wet ecosystems. Geographically, aquatic ecosystems in temperate, tropical and arctic regions, and both basic and applied science will be covered.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Know the physico-chemical environment, and its role in aquatic ecosystem.
- Learn about adaptations exhibited by organisms to survive in these typical conditions.
- Realize how human activities influence the physicochemical environment of water bodies, and devastating impact it has on aquatic organisms.
- Learn about the laws governing the use of freshwater systems, as well as the local, state, federal, and international agencies that enforce these laws to protect endangered and vulnerable species.
- Understand and apply relevant scientific principles in the area of aquatic biology and educate others or work to conserve our natural resources.

Course Content:

Theory [Credits: 4] 60hrs

<u>Unit 1</u>: Aquatic Biomes 6 hrs

Brief introduction of the aquatic biomes: Freshwater ecosystem (lakes, wetlands, streams and rivers), Estuaries, Intertidal zones, Oceanic pelagic zone, Marine benthic zone and Coral reefs.

(Chapter 10: Odum; Chapter 8: Wetzel)

<u>Unit 2</u>: Aquatic Resources 10 hrs

Important fin and shellfish resources of Inland (major carps, Catfish & prawn), Brackish water (Hilsa), Marine (demersal and pelagic), Ornamental and sport fishes.

(Chapter 3: Odum)

<u>Unit 3</u>: Freshwater Biology 24hrs

Lakes: Origin and classification, Lake as an Ecosystem, Lake morphometry, Physico–chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide). Streams: Different stages of stream development, Physico-chemical environment, Adaptation of hill-stream fishes.

(Chapter 4, 5 and 10: Odum; Chapter 2, 5, 6 and 19: Golterman; Chapter 3, 5, 7, 12, 13 and 24: Wetzel)

<u>Unit 4</u>: Marine Biology 10hrs

Salinity and density of Sea water, Continental shelf, Adaptations of deep sea organisms, Coral reefs, Sea weeds.

(Chapter 10: Odum)

<u>Unit 5</u>: Management of Aquatic Resources 10hrs

Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation (legislations), Sewage treatment Water quality assessment- BOD and COD.

(Chapter 3: Odum; Chapter 17and 19: Golterman; Chapter 13: Wetzel)

Practical [Credits: 2]

1. Determine the area of a lake using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.
3. Determine the amount of turbidity/transparency, dissolved oxygen, free carbon dioxide, alkalinity (carbonates & bicarbonates) in water collected from a nearby lake/ water body.
4. Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.
5. A Project Report on a visit to a Sewage treatment plant/Marine bio-reserve/Fisheries Institutes.

Teaching and Learning Process:

In addition to the traditional way of chalk and board teaching, teaching would be supplemented withVideo/animations to help better understanding of the subject. For enhanced practical/field driven knowledge of students, they would be taken to laboratories or Aquatic research institutes/industries.

Assessment Methods:

- Power point presentations
- Assignments with emphasis on recent studies in the Aquatic Biology
- Written examination.

Keywords:

Fresh water, Marine Biology, Aquatic resources, Management of resources

Recommended Books:

Goldman. Limnology.II Edition

Odum and Barrett. Fundamentals of Ecology.V Edition

Suggested Readings:

Pawlowski. Physicochemical Methods for Water and Wastewater Treatmen.I Edition

Wetzel. Limnology. III edition

Trivedi and Goyal. Chemical and Biological Methods for Water Pollution Studies

Online Tools and Web Resources:

- MOOC https://swayam.gov.in/courses/5686-animal-diversity

ZH GE IV: Environment and Public Health

Course Learning Objective:

Health is wealth but this wealth is directly affected by the environment. Environmental issue that affects human health is the most important trigger that has led to the urgency of conservation of environment. All the aspects of human health, including quality of life are determined by physical, chemical, biological, social and psychological factors in environment. The sustenance of environment is the key to development of future of mankind.This courseaims to create awareness among students about the necessity conservation of Mother Nature. The main objective of the syllabus is to assess, correct, control and prevent those factors that can adversely affect environment and hence health of present and future generation.

Course Learning Outcome:

Upon completion of course, students will be able to:

- Get familiarizedwith various aspects of environmental risks and hazards.
- Recognize the climate change due to human activities.
- Be aware about the various impacts of environmental degradation on human health through case studies and how it can be prevented.
- Learn about the nuclear and chemical disaster;s and their after effects through cases studies.
- Know various waste management technologies and their utility.
- Understand the diagnostic methods of various diseases and ways to prevent them.
- Realize the importance of nature conservation for betterment of human race and all living beings.

Course Content:

Theory [Credits: 4] 60hrs

Unit1: Introduction 10hrs

Sources of Environmental hazards, Hazard identification and accounting, Bioaccumulation, Biomagnification, Dose Response Evaluation, exposure Assessment.
(*Chapter 18, 22, 23: Chirac)*

Unit 2: Climate Change 10hrs

Greenhouse gases and global warming, Acid rain, Ozone layer destruction, *El Nino La Nina,* Southern Oscillation (ENSO), Effect of climate change on public health
(Chapter 9: Vasudevan; Chapter 26: Subhramaniam; Chapter 12: Park; Chapter 33: MishraandPandey)

Unit 3: Pollution 15hrs

Air, water, noise pollution: Sources, effects and control
Smog: Causes and its effect on human health, Effect of noise on Human health, Water borne diseases, Respiratory ailments (Asthma). Nuclear accidents and holocaust. Case Histories and their aftermath of: Bhopal gas tragedy, Chernobyl disaster, Seveso disaster and Three Mile Island accident.
(Chapter 7, 9 and 10: Vasudevan; Chapter 26: Subhramaniam; Chapter 12: Park; Chapter 3, 5: Bullard and Filborn; Chapter 1: Crowland. Louvar)

<u>Unit 4:</u>Waste Management Technologies 15hrs

Classification and Characteristics of solid and hazardous waste, Sewage treatment and its management, Solid waste management, Handling and disposal: Biomedical waste and Nuclear waste, Health risk due to hazardous waste (Minamata disease)

(Chapter 7 and 11, Vasudevan; Chapter 12: Park; Chapter 33: Mishra and Pandey)

<u>Unit 5:</u>Diseases 10hrs

Causes, symptoms and control of tuberculosis,Vector borne diseases (Dengue, Malaria), Typhoid, Cholera, Cancer, Infectious diseases

(Chapter 5 and 6: Park)

Practical [Credits: 2]

1. To determine pH, Cl, SO_4, NO_3 in soil samples from different locations.
2. To determine pH, Cl, SO_4, NO_3 in water samples from different locations.
3. To determine dissolved oxygen in water samples collected from different water bodies by Winkler's Method
4. To measure the COD of water sample from various sources
5. To study the methods adopted for segregation of domestic and hospital wastes into different categories.
6. A report based on a visit to thermal power plant/ solid waste management site/ Sewage Treatment Plant/ Nuclear Power Plant

Teaching and Learning Process:

Generic Elective papers are interdisciplinary in nature. This paper has been revised for better understanding of the subject by the students even from unrelated disciplines. For an effective teaching learning process instead of teaching in a complete lecture mode, there should be interactive teaching for better understanding of the topic. The topics under Waste management can be understood through visits to waste treatment plants.There can be extended practical other than the ones included in the syllabus which may include collection of data, data analysis and preparing report.Incorporation of media and multimedia andscreening of documentaries/movies relevant to the current scenario of environmental degradation will create awareness among students.Students can present case studies or Government's initiative relevant to the topics related to the paper. Quizzes and debates can be used for better understanding of the topics. Continuous evaluation through tests, presentation, assignments and project work will inculcate in-depth understanding of the subject.

Assessment Methods:

The various methods can be adopted for continuous evaluation of the students:

- Regular class test
- Oral presentation as part of assignment
- Participation in discussion
- Project work with viva
- Performance in regular and extended practical

Keywords:

Environment, Pollution, Environmental hazards, Public Health, Climate Change, Waste management technologies

Recommended Books:

- Vasudevan, N. (2006)., Essentials of Environmental Science, Narosa Publishing house, Delhi,
- Park, K., Parks (2016). Text Book of Preventive & Social Medicine, 23rd Edition, Banarsidas Bhanot Publishers
- N. S. Subrahmanyam and A. V. S. S. Sambamurty (2017). Ecology, Second Edition Reprint Narosa Publishing house, ISBN: 978-81-7319-740-6
- Chirac, Daniel, D. (2012). Environmental Science, IXth Edition, Jones and Bartlett, India Ltd.
- Misra, S.P.and Pandey, S.N. (2016). Essential Environmental studies. 4thEdition Ane Books Pvt. Ltd.

Suggested Readings:

- Kolluru Rao, Bartell Steven, Pitblado R and Stricoff (1996). Risk Assessment and Management Handbook. McGraw Hill Inc., New York.
- Kofi Asante Duah (1998). Risk Assessment in Environmental Management. John Wiley and sons, Singapore.
- Kasperson, J.X. and Kasperson, R.E. and Kasperson, R.E. (2003). Global Environmental Risks. V.N. University Press, New York.
- Joseph F Louvar and B Diane Louver (1997). Health and Environmental Risk Analysis:Fundamentals with applications. Prentice Hall, New Jersey.

Online Tools and Web Resources:

- e-PG Pathshala, SWAYAM, Coursera, Khan academy, CMS vatavaran documentaries,
- BBC, Discovery, National geographic, Science Insider

ZH GE V Exploring The Brain: Structure And Function

Course Learning Objective:

Exploring the Brain Structure and function is designed for science undergraduates with the aim to provide them an understanding of neural structures as well as its functions which are prerequisites for higher studies in neurology and psychiatry courses. This introductory course will lead students to explore the nervous system on multiple levels. They will learn about the structure of human brain as well as cellular & molecular components of nervous system which come together in neuronal circuits for conducting signals and memory consolidation. This course is also designed to familiarize students with different neurological disorders, neuro-physiological as well as neuro-imaging techniques used for its diagnosis. Overall, this course will provide students basic knowledge and awareness about field of neuroscience. The course content is mapped to provide an overview of brain anatomy and various aspect of nervous system to our undergraduates who wish to pursue higher studies or research in the field of neuroscience.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Define the cellular- and anatomical-level organisation of the brain.
- Understand the properties of neuronal and non-neuronal cells that make up the brain including the propagation of electrical signals used for cellular communication.
- Comprehend how the interaction of cells and neural circuits leads to various higher level activities like cognition and behaviour.
- Identify principles /mechanism underlying various neurological disorders.
- Learn about neuroimaging methods used for disease diagnosis; and neurophysiological methods for sleep and epilepsy analysis.

Course Content

Theory [Credits: 4] 60 hrs

Unit 1: Introduction 3 hrs

Historical views of the Brain; Neuron doctrine; Organisation and Classification of nervous system.

(Chapter 1 and 2: Mark F. Bear)

Unit 2: Evolution and Adaptation of Brain 6 hrs

Brain evolution and behavioral adaptation; Theories of brain evolution – involving addition of structure or areas, involving new formation and reorganisation of circuits.

(Chapter 16 and 17: Kent and Carr)

Unit 3: Cellular Neurobiology 8hrs

Neurons and Glia: Neurons - Soma, Axon, Dendrite; Classification of Neurons; Glia - Astrocytes, Oligodendrocytes and other non-neuronal cells. Action potential: its generation and propagation. Synapse: Types of synaptic transmission, Principles of synaptic transmission and synaptic integration.

(Chapter 7: Mark F. Bear)

Unit 4: Understanding Brain Structure through Development 14 hrs

Formation of neural tube, Primary brain vesicles; Differentiation of forebrain, midbrain and hindbrain.Cerebral cortex - neocortical evolution and structure-function relationship.Gross anatomy of human brain, Spinal cord; Cranial nerves, Meninges, ventricular system.
(Chapter 4, 5: Mark F. Bear; Chapter 4- 13: ER Kandel)

Unit 5:Chemical Control of Brain, Behaviour, Learning& Memory 18 hrs
Structure and functions of hypothalamus, pituitary and pineal glands. Diffuse modulatory systems of the brain - noradrenergic, serotonergic, dopaminergic and cholinergic system.Neurotransmitters, Ionotropic and metabotropic receptors. Molecular basis of learning and memory formation: role of the cortex, and hippocampus. Synaptic plasticity and memory consolidation
(Chapter 6, 15, 20: Mark F. Bear; Chapter 65: ER Kandel; Chapter 7, 8, 10: JH Byrne)

Unit 6:Rhythms of the Brain 4 hrs
Biological Rhythms: Circadian Rhythms and Zeitgebers, Role of the suprachiasmatic nucleus in regulating circadian rhythms, Electroencephalogram; Sleep rhythms, neural mechanisms of sleep.
(Chapter 20: JH Byrne; Chapter 51: ER Kandel)

Unit 7:Neurological Disorders 7 hrs
Molecular neurodegeneration in Alzheimer and Parkinson disease. Psychosocial and biological approaches to mental illness like Obsessive-Compulsive Disorder (OCD); Attention-Deficit/Hyperactivity Disorder (ADHD) and Schizophrenia.Neuroimaging techniques: PET,CT and MRI imaging for disease diagnosis.
(Chapter 21: Mark F. Bear; Chapter 63: ER Kandel)

Practical [Credits: 2]

1. Dissection and study of *Drosophila* nervous system.
2. Observation and quantitation of *Drosophila* photoreceptor neurons.
3. Perform histochemistry of spinal cord and brain to identify neurons and subcortical structures.
4. Action potential: simulations under normal conditions and in presence of toxins.
5. Prepare a brief project on electrophysiological hallmark of sleep-wake staging or epileptogenesis.

Teaching and Learning Process:

Knowledge will be shared between teacher and students through two-way communication. Learning among students will be facilitated by using problem solving exercises, elaborative quiz-based learning, smart class-based teaching, using multimedia and animation videos as well as interactive sessions.They will be motivated to take up mini-project works, prepare models and participate in group discussions for increasing their awareness about experimental neuroscience.

Assessment Methods:

The learners/ students can be assessed in the following ways:

- Continuous assessment will be made during entire semester. Summative assessment will be collected through as mid semester and semester end evaluations.
- Students will be asked to give powerpoint or black-board presentation on related topics to increase their basic presentation skills and knowledge.

- Students will be provided feedback on assignments to improve their writing skills and academic performance.
- From time to time learners will be given theoretical and practical problems to test their theoretical skills and promote practical knowledge.

Keywords:

Neuroscience, Neuroanatomy, Circadian rhythms, Sleep, Neurochemistry, Action potentials, Learning and memory, Synaptic plasticity, Neurotransmitters, Cognitive, Neurodegenerative diseases, Alzheimer, Parkinson disease.

Recommended Books:

- Mark F. Bear, Barry W. Connors, Michael A. Paradiso (2015). Neuroscience: Exploring the brain. IV Edition.
- ER Kandel, JH Schwartz and TM Jessell (2010). Principles of Neural Science.IV Edition, , McGraw-Hill Companies.
- John H. Byrne. Ruth Heidelberg and M. Neal Waxham. From Molecules to Networks: An Introduction to Cellular and Molecular Neuroscience.

Suggested Readings:

- Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P (eds). (2002). Molecular Biology of the Cell.IV Edition, New York: Garland.
- Kelly R.B. (1993). Storage and release of neurotransmitters. Cell 72:43–53.
- Kimelberg H.K. (2010). Functions of mature mammalian astrocytes: A current view. The Neuroscientist 16:79–106.
- Bezanilla F. (2008). Ion channels: from conductance to structure. Neuron 60:456–468.
- Goedert M. and Spillantini M.G. (2006). A century of Alzheimer's disease. Science 314:777–781. Peter J Simmons and David Young-CUP-2003, Nerve Cells and Animal Behaviour. II Edition.
- Stephan M. Stahl-CUP-2000, Essential Psychopharamacology- Neuroscientific Basis and Practical Applications, II Edition.
- Vilayanur S. Ramachandran and Sandra Blakeslee (1998). Phantoms in the Brain
- Rita Carter (2009). The Human Brain Book

Online Tools and Web Resources:

- Learn Medical Neuroscience. Virtual Lab. https://www.learnmedicalneuroscience.nl/virtual-lab/sensory-systems/
- Allen Brain Atlases:http://portal.brain-map.org
- Human Brain project:https://www.humanbrainproject.eu/en/
- Neuroscience learning resource: https://www.hhmi.org/biointeractive/neuroscience-collection
- JoVE Science Education. https://www.jove.com/science-education-library
- Coursera- Introduction to Neuroanatomy.
- Coursera- General principles of sensory system part 1 and 2.
- Swayam (MHRD) Portal:
  - ✓ Demystifying The Brain online course –Neuroscience of Human Movement online
  - ✓ How The Brain Creates Mind online course
  - ✓ Learning about Learning: A Course on Neurobiology of Learning and Memory
  - ✓ Cognitive Science online course

ZH GE-VI Food, Nutrition and Health

Course Learning Objective:

The prime focus is to provide the students with a basic understanding of the relationship between food, nutrition and health. It is imperative that focus should be on realistic issues faced by people with respect to nourishment at all stages of life.Unhealthy eating habits particularly the shift from fresh food consumption to packaged foods with added salts and preservatives have contributed to the obesity epidemic in nearly all parts of the world. It is important to understand this link and change eating habits in accordance to one`s age, pregnancy, lactation and physical activity.By taking steps to eat healthy, one can obtain the nutrients required by the body to stay healthy, active, and strong. Mental health is also affected largely by our lifestyle. Apart from physical activity, the intake of the required vitamins, minerals and antioxidants alsonourish the brain. Malnutrition is the main cause of impairment of growth in young children and infants and leads to diseases like Marasmus. Moreover, food hygiene includingfood and water borne infections along with food spoilage has also been covered in this course.

Course Learning Outcome:

Upon the completion of the course, students will be able to:

- Have a better understanding of the association of food and nutrition in promoting healthy living.
- Think more holistically about the relationship between nutrition science, social and health issues.
- Move on to do post-graduation studies and can apply for jobs as food safety officers, food analysts, food inspectors, food safety commissioners or controllers for jobs in organizations like FSSAI.
- Specialize in various fields of nutrition.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Basic concept of food and nutrition 13hrs

Food Components and food-nutrients, Concept of a balanced diet, nutrient needs and dietary pattern for various groups- adults, pregnant and nursing mothers, infants, school children, adolescents and elderly. Food Pyramid, Nutritional anthropometry- BMI, waist-to-hip ratio, skin-fold test and bioelectrical impedance; interpretation of these measurements.
(Part 1, 5 and 6: Mann and Truswell; Chapter 1, 7 and 11: Gibney)

Unit 2: Nutritional Biochemistry 15hrs

Carbohydrates, Lipids, Proteins, their dietary source and role Vitamins- their dietary source and importance Minerals- their biological functions.Dietary Fibres - Definition, their dietary source and nutritional importance. Elementary idea of Probiotics, Prebiotics, Organic Food.
(*Part 1 and 2: Mann and Truswell; Chapter 8 and 9: Gibney; Chapter 1, 2, 4, 5 and 7: Lee and Salminen)*

Unit 3: Health 17hrs

Definition and concept of health, Major nutritional Deficiency diseases- (kwashiorkor and marasmus), Deficiency disorders, their causes, symptoms, treatment, prevention and government programmes, if any. Life style related diseases- hypertension, diabetes mellitus, Atherosclerosis and obesity- their causes and prevention through dietary and lifestyle

modifications, Social health problems- smoking, alcoholism, drug dependence and Common ailments- cold, cough, and fevers, their causes and treatment.
(Chapter 1 and 2: Robinson; Chapter 8: Gibney; Chapter 4, 6, 7, 13 and 18: Elia)

Unit 4: Food hygiene 15 hrs
Food and Water borne infections;Bacterial infection: Cholera, typhoid fever, dysentery; Viral infection: Hepatitis, Poliomyelitis;Protozoan infection: amoebiasis, giardiasis; Parasitic infection: taeniasis and ascariasis their transmission, causative agent, sources of infection, symptoms and prevention; Brief account of food spoilage: Causes of food spoilage and their preventive measures.

(Chapter 14 and 15: Gibney; Chapters 2, 3 and 5: Hawker; Part I and II: Clive de W Blackburn)

Practical [Credits: 2]

1. To detect adulteration in a) Ghee b) Sugars c) Tea leaves and d) Turmeric
2. Estimation of Lactose in milk and diagnosis of lactose intolerance by measuring hydrogen gas during expiration.
3. Ascorbic acid estimation in food by titrimetry
4. Estimation of Calcium in foods by titrimetry
5. Study of the stored grain pests from slides/photographs (*Sitophilus oryzae, Trogoderma granarium, Callosobruchus chinensis*and *Tribolium castaneum*): their identification, habitat and food sources, damage caused and control. Preparation of temporary mounts of the above stored grain pests.
6. Visit to food testing lab /or any agency of food standards
7. Project work
8. Undertake computer aided diet analysis and nutrition counselling for different age groups.
9. Identify nutrient rich sources of foods (fruits and vegetables), their seasonal availability and price.
10. Study of nutrition labelling on selected foods

Teaching and Learning Process:

Lectures using PowerPoint and chalk-blackboard method & RBPT will be used to impart knowledge. Use of IT-CT facility will be integrated in the learning. Survey based short projects as assignments will help students to gain insight in the subject. Visit to prominent food and nutrition laboratories to learn about basic techniques will arouse interest among students.

Assessment Methods:

- Quizzes, multiple choice questions, fill in the blanks and short answers
- Student presentation
- Take-home Assignments
- End of term theory and Practical examination

Keywords:

Food, Nutrition, Health, Food Pyramid, Diseases

Recommended Books:

- Shashi Goyal & Pooja Gupta. Food, Nutrition and Health (ISBN: 9788121940924)
- Linda Tapsell. Food, Nutrition and Health. I Edition, Oxford (ISBN: 978-0195518344)

- Gibney MJ et al. (eds) (2009) Introduction to Human Nutrition. Wiley-Blackwell A John Wiley & Sons Ltd, Nutritional Society.
- Mann J and Truswell SA, Essentials of Human Nutrition, Oxford University Press
- Yuan Kun Lee and Seppo Salminen: Handbook of Probiotics and Prebiotics, second ed., John Viley & Sons, Inc.
- James Robinson, Deborah J McCornick, Concepts in Health and Wellness, Delmar Cenage Learning, 1st ed
- Jeremy Hawker, Norman Begg, Iain Blair, Ralf Reintjes, Julius Weinberg, Communicable Disease Control Handbook, 2nd ed
- Clive de W Blackburn, Food Spoilage Microorganisms, Woodhead Publishing Limited, cambridge

Suggested Readings:

- Avantina Sharma. Principles of Therapeutic Nutrition and Dietetics.. CBS Publishers and Distributors Pvt. Ltd.
- Elia M et al. (eds) Clinical Nutrition. Wiley-Blackwell A John Wiley & Sons Ltd.

ZH GE-VII: Human Physiology

Course Learning Objective:

The students will be introduced to the principles of normal biological function in human body. Basic human physiology will be outlined and correlated with histological structures. Students will be exposed to the concept of how animals maintain an internal homeostatic state in response to changes in their external environment. Hands-on practical skills useful in routine life will be inculcated among students. Students will be encouraged for subsequent biological courses that require an understanding of the physiology of organisms.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Know the principles of normal biological function in human body.
- Outline basic human physiology and correlate with histological structures.
- Understand how animals maintain an internal homeostatic state in response to changes in their external environment.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Digestion and Absorption of Food 12 hrs

Structure and function of digestive system; Digestion and absorption of carbohydrates, fats and proteins; Nervous and hormonal control of digestion (in brief)

(Chapter 24: Tortora & Derrickson)

Unit 2: Functioning of Excitable Tissue (Nerve and Muscle) 10 hrs

Structure of neuron and brief introduction of neuroglia; Propagation of nerve impulse (myelinated and non-myelinated nerve fibre); Structure of skeletal muscle; Mechanism of muscle contraction (Sliding filament theory); Neuromuscular junction

(Chapter 12 and 10: Tortora & Derrickson)

Unit 3: Respiratory Physiology 8 hrs

Structure and function of respiratory tract and Lungs; Ventilation, External and internal respiration; Transport of oxygen and carbon dioxide in blood; Factors affecting transport of gases

(Chapter 23: Tortora & Derrickson)

Unit 4: Renal Physiology 8 hrs

Functional anatomy of kidney; Mechanism and regulation of urine formation

(Chapter 26: Tortora & Derrickson)

Unit 5: Cardiovascular System 8 hrs

Structure of heart; Coordination of heartbeat; Cardiac cycle and ECG

(Chapter 20: Tortora & Derrickson)

Unit 6: Endocrine and Reproductive Physiology 14 hrs

Structure and function of endocrine glands and related disorders (pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries, and testes); Brief account of spermatogenesis and oogenesis; Menstrual cycle

(Chapter 18 and 28: Tortora & Derrickson)

Practical [Credits: 2]

1. Preparation of temporary mounts: Neurons and Blood film.
2. Preparation of haemin and haemochromogen crystals.
3. Demonstration of haemoglobin using Sahli's haemoglobinometer.
4. Examination of permanent histological sections of mammalian, stomach, lung, kidney, thyroid, pancreas, testis, ovary.
5. Determination of ABO Blood group.
6. Recording of blood pressure using a Sphygmomanometer in resting condition.

Teaching and Learning Process:

Interactive learning using classic lecture mode, Power Point Presentations, Discussion, Audio Visual aids, etc. will be used to create awareness and interest among students.

Assessment Methods:

- Diagnostic assessment- to check the knowledge base. It is desired, as being a Generic Elective paper, students would come from diverse streams (science, commerce and arts).
- Formative assessment- written test/*viva-voce* to check the retention of the topic.
- At the end, summative assessment could be done and students to be rewarded on the basis of presentations, test, project reports, theory and practical examination.

Keywords:

Physiology, Histology, Anatomy, Physiological pathways, Feed-back loops, Control and coordination.

Recommended Books:

- Widmaier E, Raff H and Strang K. (2013) Vander's Human Physiology: The Mechanism of Body Function**s**. McGraw-hill Education XIIIth Edition.
- Tortora, G.J. and Derrickson, B.H. (2009). Principles of Anatomy and Physiology. XII Edition, John Wiley and Sons, Inc.

Suggested Readings:

- Guyton, A.C. and Hall, J.E. (2011) Textbook of Medical Physiology. XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
- Kesar, S. and Vashisht, N. (2007) Experimental Physiology. Heritage Publishers.
- Prakash, G. (2012) Lab Manual on Blood Analysis and Medical Diagnostics. S. Chand and Company Ltd.

Online Tools and Web Resources:

- e portals like SWAYAM
- http://nsdl.niscair.res.in

ZH GE-VIII Insect Vector and Disease

Course Learning Objective:

Insect vectors cause many diseases which lead to millions of deaths across the world every year especially in developing countries. The rate of pathogen transmission by insects is increasing at an alarming rate posing a growing threat to the human population. Disease transmission by these insects can be prevented only by studying their biology, modes of transmission of pathogens by them, evaluation of associated risk factors, devise effective methods to control these insects and resolve the challenges posed.

Course Learning Outcome:

Upon completion of the course, the students will be able to:

- Identify different insects and classify them based on their morphology and behaviour
- Describe the host-pathogen relationships and the role of the host reservoir on transmission of parasite
- Explain various modes of transmission of parasite by insect vectors
- Recognize various possible modern tools and methodologies for laboratory diagnosis, surveillance and treatment of diseases
- Define various terms related to insect transmitted diseases such as vectorial capacity, mechanical and biological transmission, host specificity etc.
- Identify the risk groups and characterize them on the basis of exposure risk
- Explain control methods of insect vector diseases including spreading awareness on public health programs and mitigating insect borne diseases
- Employ the use of advanced management strategies in disease control with respect to parasite evolution

Course Content:

Theory [Credits:4] 60 hrs

<u>Unit 1</u>: Introduction to Insects 10 hrs

General Features of Insects, Classification of insects up to Orders- key identification features; Morphological features: Head- Eyes, Types of antennae, Types of Mouth parts *w.r.t.* feeding habits: siphoning type (butterfly), sponging type (housefly), biting and chewing type (cockroach), piercing and sucking type (mosquito), chewing and lapping type (honey bee); thorax: types of legs.

(Chapters 2 and 3: Service, M.W.; Chapters 1 and 2: Richard P. Lane & Roger W. Crosskey)

<u>Unit 2</u>: Concept of Vectors 4 hrs

Brief introduction to carriers and vectors (mechanical and biological vector); Insect reservoirs; Host-vector relationship; Vectorial capacity; Adaptations in insects to act as vectors; Host Specificity; Modes of disease transmission- vertical and horizontal transmission.

(Chapters 1 and 2: Service, M.W.; Chapter 1: Richard P. Lane & Roger W. Crosskey)

<u>Unit 3</u>: Insects as Vectors 10 hrs

Features of Orders with insects as vectors (Diptera, Siphonaptera, Siphunculata, Hemiptera) *w.r.t.* evolutionary, anatomical, physiological, cellular and molecular adaptations towards their role as vectors; Management strategies to control insect vectors- quarantine, cultural, mechanical, chemical, biological, behavioural.

(Chapters 1 and 2: Service, M.W.; Chapter 2: Richard P. Lane & Roger W. Crosskey)

<u>Unit 4:</u> Dipterans as Disease Vectors 20 hrs

Dipterans as important insect vectors- Mosquitoes, Sand flies, Houseflies; Study of mosquito borne diseases- Malaria, Dengue, Chikungunya, Viral encephalitis, Filariasis; Control of mosquitoes; Study of sand-fly borne diseases- Leishmaniasis, phlebotomus fever; Control of sand flies. Study of house fly as important mechanical vector; Myiasis; Control of housefly.
(Chapters 4, 5, 6, 8 and 12: Service, M.W.; Chapters3, 4,5 and 11: Richard P. Lane & Roger W. Crosske)

<u>Unit 5</u>: Siphonapterans as Disease Vectors 5 hrs

Fleas as insect vectors; Host-specificity; Study of flea borne diseases- Plague, typhus fever; Control of sand flies.
(Chapter 15: Service, M.W.; Chapter 16: Richard P. Lane & Roger W. Crosskey)

<u>Unit 6</u>: Siphunculata as Disease Vectors 6 hrs

Human louse (head, body and pubic louse) as disease vectors; study of louse borne diseases- Typhus fever, relapsing fever, trench fever, vagabond's disease, phthiriasis; Control of human louse.
(Chapter 16: Service, M.W.; Chapter 15: Richard P. Lane & Roger W. Crosskey)

<u>Unit 7</u>: Hemipterans as Disease Vectors 5 hrs

Bugs as insect vectors; Blood sucking bugs; Chagas disease; Bed bugs as mechanical vectors; Control and prevention methods.
(Chapter 17 and 18: Service, M.W.; Chapter 14: Richard P. Lane & Roger W. Crosskey)

Practical [Credits: 2]

1. Study of different kinds of mouth parts of insects through slides/specimens
2. Study of insect vectors through permanent slides or photographs: *Aedes, Culex, Anopheles,* lice (head, body, pubic), bed bug, *Phlebotomus* (sand fly), *Musca domestica* (house fly)
3. Study of different diseases transmitted by above insect vectors.
4. Project report on any one disease transmitted by insect vector

Teaching and Learning Process:

Classroom teaching using Power point presentations enabled with related photographs of insect vectors, their life stages and disease diagnosis will be employed to clarify concepts. Case studies of epidemics caused by insects as vectors will be discussed to make the students aware about their importance. Visit to local diagnostic centre will provide an overview of various medical tests conducted to detect and confirm vector transmitted diseases.

Assessment Methods:

- Continuous and Comprehensive Formative assessment (attendance, assignment and test)
- *Viva-voce: Viva-voce* is a critical component of assessment of the practical component of a course. Inquiry-based learning
- Summative Assessment
- Term-end Theory exam
- Term-end Practical exam

Keywords:

Insect, Vector, Diseases, Mosquito, Host, Parasite

Recommended Books:

- Service, M.W. (1980) A Guide to Medical Entomology. Macmillan Press.
- Ricard P. Lane and Crosskey R. W. (1993) Medical insects and Arachnids. Springer Science and Business Media, B. V.
- Burgess, N.R.H and Cowan, G.O. (1993) A Colour Atlas of Medical Entomology. Springer Science and Business Media, B. V.

Suggested Readings:

- Kenneth G. V. Smith. (1973) Insects and other Arthropods of Medical Importance. John Wiley and Sons.
- Nicholas R. H. Burgess. (1981) Arthropods of Medical Importance. Noble Books Ltd. Hampshire

ZH SEC-I Apiculture

Course Learning Objective:

The course will make the student aware about the significance of beekeeping as the economically viable industry. It will help the students to understand the biology and behaviour of bees. The course would clarify the techniques of honey bee rearing, optimization of techniques based on climate and the geographical regions, and various measures to be taken to maximize the benefits. It would also help the students to develop entrepreneurial skills required for self-employment in beekeeping sector.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Learn about the various species of honey bees in India, their social organization and importance.
- Be aware about the opportunities and employment in apiculture- in public, private and government sector.
- Gain thorough knowledge about the techniques involved in bee keeping and honey production.
- Know about various products obtained from beekeeping sector and their importance.
- Develop entrepreneurial skills necessary for self-employment in beekeeping sector.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Course Content:

Theory [Credits: 2] 30 hrs

Unit1: Biology of Bees 4 hrs

History, Classification and biology of Honey Bees, different species of honey bees-*Apis dorsata, Apiscerana indica, Apisflorea, Apis mellifera, Melipona* sp. Social Organization of bee colony, behavioural patterns (Bee dance, swarming)

(Chapter 1, 2 and 3: Singh, S.; Chapter 2, 3 and 5: Mishra, R.C.)

Unit 2: Rearing of Bees 14 hrs

Artificial bee rearing (Apiary), Beehives- Newton and Langstroth; Bee Pasturage; Selection of bee species for Apiculture- *Apiscerana indica, Apis mellifera*; Bee keeping equipment, Methods of extraction of Honey (Indigenous and Modern) and processing; Apiary management- Honey flow period and Lean period

(Chapter 4, 5, 6 and 7: Singh, S.; Chapter 4, 8 and 9: Mishra, R.C.)

Unit 3: Diseases and Enemies 5 hrs

Bee diseases, control and preventive measures; Enemies of bees and their control

(Chapter 10: Singh, S.; Chapter 10: Mishra, R.C,
Chapter 6: https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)

Unit 4: Bee Economy 3 hrs

Products of Apiculture Industry (Honey, Bees Wax, Propolis, Royal jelly, Pollen etc.) and their uses; Modern methods in employing artificial beehives for cross pollination in horticultural gardens

(Chapter 11: Singh, S.; Chapter 11 and 12: Mishra, R.C.Chapter 9: https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)

Unit 5: Entrepreneurship in Apiculture 4 hrs

Bee Keeping Industries- Recent efforts, Employment opportunities, Economics in small scale and large-scale beekeeping, Scope for women entrepreneurs in beekeeping sector

(Chapter 10: https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf Entrepreneurial Potential of Small-scale Beekeeping in Rural India: A Case in Kanyakumari district, Tamil Nadu. M. Esakkimuthu & VLV. Kameswari, Tropical Agricultural Research, (2017) 28: 411)

Practical [Credit: 2]

1. Study of the life history of honey bee, *Apiscerana indica* and *Apis mellifera* from specimen/ photographs - Egg, larva, pupa, adult (queen, drone, worker)
2. Study of natural bee hive and identification of queen cells, drone cells and brood
3. Study of morphological structures of honey bee through permanent slides/photographs- mouth parts, antenna, wings, legs (antenna cleaner, mid leg, pollen basket), sting apparatus.
4. Permanent/temporary mount of antenna cleaner, mid leg and pollen basket OR mount of pollen grains from flowers
5. Study of artificial hive (Langstroth/Newton), its various parts and beekeeping equipment.
6. Analysis of honey- purity, biochemical analysis (Any two constituents)
7. Visit to an apiary/honey processing unit/Institute and submission of a report.
   a. Study of bee pasturage
   b. Visit to fields/gardens/orchards for studying the bee activity (role in pollination and nectar collection).
   c. Making of herbarium of nectar and pollen yielding flowering plants
8. Submission of a few products obtained from apiculture industry.

Teaching and Learning Process:

Information and concepts about benefits of honey bees in human life and how these benefits can be reaped, will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of bees in nature and study of rearing technology will be assisted through visits to various apiculture institutes which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs. Blended learning including chalk-n-talk method and e-learning will be encouraged to make learning by students more dynamic. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of bee biology will be promoted to not only ensure effective learning and understanding of the concepts, but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware about handling of bees and their rearing methods. Collection of plants and bee products will also help students to know the benefits of apiculture. Visit to various apiculture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:

Various measures adopted will be as follows.

- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones in which evaluation is held.

- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcome will be held.
- Regular Presentations: Presentations by the students on a topic will enhance their learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries.
- *Viva-voce: Viva-voce* is a critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of their learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

Keywords:
Apiculture, Bee, Bee hive, Beekeeping, Bees' wax, Brood, Comb sheets, Drones, Entrepreneurship, Honey, Langstroth's hive, Newton's hive, Propolis, Queen bee, Royal jelly

Recommended Books:
- Singh S. (1962) Beekeeping in India, Indian Council of Agricultural Research, New Delhi.
- Mishra, R. C. (1995) Honeybees and their Management in India. Indian Council of Agricultural Research, New Delhi.

Suggested Readings:
- Prost, P. J. (1962) Apiculture. Oxford and IBH, New Delhi.
- Rahman, A. (2017) Beekeeping in India. Indian Council of Agricultural Research, New Delhi
- Gupta, J. K. (2016) Apiculture, Indian Council of Agricultural Research, New Delhi

Online Tools and Web Resources:
- (https://www.ecornell.com/certificates/beekeeping/master-beekeeping/)
- Beekeeping (https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)
- Swayam (MHRD) Portal Vocational Beekeeping (https://swayam.gov.in/courses/5844-vocational-beekeeping

ZH SEC -II Aquarium Fish Keeping

Course Learning Objective:

The course will impart basic knowledge of ornamental fish Industry and inculcate its scope as an avenue for career development as an entrepreneur or as an aquari-culturist. It will provide a clear understanding of the basics of biology and habits of aquarium fish, so as to facilitate taking up ornamental fish keeping as an enterprise, even at the household level. The skill capacity building of students will be promoted by teaching the techniques of aquarium constructions, feed formulation and preparation, transportation, maintenance and management of the system. Students will have 'hands-on' experience by exposure to technology, production, functioning or operation of an institution through visits to public aquariums in the markets, ornamental fish farms, hatcheries, and fish feed production plant as study tours or field visits.

Course Learning Outcome:

- Upon completion of the course, students should be able to: Acquire knowledge about different kinds of fish their compatibility in aquarium.
- Become aware of Aquarium as commercial, decorative and of scientific studies.
- Develop personal skills on maintenance of aquarium.
- Know about the basic needs to set up an aquarium, i.e., dechlorinated water, reflector, filters, scavenger, aquatic plants etc. and the ways to make it cost-effective.

Course Content:
Theory [Credits: 2] 30 hrs

Unit 1: Introduction to Aquarium Fish Keeping 2 hrs

The potential scope of Aquarium Fish Industry as a Cottage Industry; Exotic and Endemic species of Aquarium Fish

(Chapter 50 and 54: Pandey and Shukla)

Unit 2: Biology of Aquarium Fish 6 hrs

Study of different species of Aquarium fish and biology (Breeding, Feeding economic importance etc) of exotic and endemic fish. Common characters and sexual dimorphism of Fresh water and marine aquarium fish such as Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish and Butterfly fish.

(*Chapter 3: Dawes)*

Unit 3: Food and Feeding of Aquarium Fish 8 hrs

Use of live fish feed organisms (Advantages and disadvantages of live food), Use of formulated feeds, Types of formulated feed, Formulation and preparation of feed, Advantages and disadvantages of formulated feed

(Chapter 50: Pandey and Shukla)

Unit 4: Fish Transportation 8 hrs

Live fish transport (Capture and Pre-transport maintenance, capture and handling techniques); Fish packing and transport (Closed and open transport system, Preparation for packaging, Procedure for packaging, Precautions, Post transport maintenance) General handling techniques

(Chapter 13, Jhingran)

<u>Unit 5</u>: Maintenance of Aquarium 6 hrs
General aquarium maintenance- budget for setting up an Aquarium Fish Farm as a cottage industry.
(Chapter 2: Dawes)

Practical [Credit: 2]

1. Study of different species of Aquarium fish and biology (Breeding, Feeding economic importance etc.) of exotic and endemic fish.
2. Study of sexual dimorphism of fresh water and marine aquarium fish (Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish, Butterfly fish)
3. Type, composition and formulation of fish feed (using Pearson Square Methods)
4. Construction and maintenance of Glass Aquarium and Filter System using indigenous Locally available materials.
5. Monitoring of aquarium water quality (temperature, pH, dissolved oxygen, carbon dioxide, ammoniacal N-load) through titrimetric methods.
6. To write a project proposal for setting up a small aquarium fish keeping as a cottage industry to a funding agency for self-employment of youths or for helping poor farmers; after visiting any farm/enterprise.

Teaching and Learning Process:

Teaching Learning must include the videos, surveys, presentation to show the significance of the course- its commercial, scientific and aesthetic prospects. Learning must include a visit to any farm or lab by students. Practical exercise with the setup of an aquarium and its maintenance; hands-on training for the formation of feeds will develop skill among students.

Assessment Methods:

- Reports
- Presentation
- Individual project reports
- Problem-solving exercises
- Observation of practical skills
- *Viva-voce*

Keywords:

Ornamental fish, Cottage industry, Endemic fish, Feed formulation, Transportation techniques.

Recommended Books:

- Dawes, J. A. (1984) The Freshwater Aquarium, Roberts RoyeeLtd.London.
- Gunther, A. (1980) An Introduction to the Study of Fishes. A and C. Black Edinburgh.

Suggested Readings:

- Jhingran, V.G. (1982) Fish and Fisheries in India. Hindustan publication Corp, India.
- Pandey, K and J.P. Shukla (2013) Fish and Fisheries. Rastogi publication

ZH SEC-III Medical Diagnostics

Course Learning Objective:
Medical diagnostics paper is aimed to provide students a unique opportunity to study how doctors or clinicians come to a conclusion regarding disease prediction, prevention, diagnosis, and optimal treatment regimens. Students will learn about multiple diagnostic tools, techniques and technologies used in medical practices. The emphasis is on, how to select an appropriate diagnostic technique, methods and technologies to conduct analyses to understand the results and their implications in patients' diagnosis. This paper primarily focuses on clinical chemistry, hematology, diagnostic microbiology, histopathology, molecular diagnostics and diagnostic medical imaging.

Course Learning Outcome:
After completing this course, the students should be able to:
Gain knowledge about various infectious, non-infectious and lifestyle diseases, tumors and their diagnosis

- Understand the use of histology and biochemistry of clinical diagnostics and learn about the molecular diagnostic tools and their relation to precision medicine.
- Develop their skills in various types of tests and staining procedure involved in hematology, clinical biochemistry and will know the basics of instrument handling.
- Learn scientific approaches/techniques used in the clinical laboratories to investigate various diseases and will be skilled to work in research laboratories.
- Gain knowledge about common imaging technologies and their utility in the clinic to diagnose a specific disease.

Course Content:
Theory [Credits: 2] 30 hrs

<u>**Unit 1**</u>**: Introduction to Medical Diagnostics and its importance** 2 hrs
(Chapter: 4 Park)

<u>**Unit 2**</u>**: Medical Diagnostics of body fluids** 10 hrs
Blood composition, Blood bank, Transfusion of blood, RBC, WBC and platelet count using haemocytometer, Erythrocyte Sedimentary Rate (E.S.R), Packed Cell Volume (P.C.V.), Analysis of urine, sputum, faeces and semen (sperm count)
(Chapter 9a, 9b, 9c, 12, 19, 20, 21: Prakash, G.)

<u>**Unit 3**</u>**: Medical Diagnostics of Non-infectious Diseases** 10 hrs
Causes, types, symptoms, complications, diagnosis and prevention of Diabetes (Type I and Type II), Hypertension (Primary and secondary), Diagnosis and detection of types of tumours (Benign/Malignant) and metastasis, FNAC.
(Chapter 16 and 22a: Prakash, G.; *Chapter 6: Park)*

<u>**Unit 4**</u>**: Diagnostics Microbiology** 5 hrs
Methods to diagnose and isolate infectious agents of diseases like Tuberculosis, Hepatitis and AIDS.
(Chapter5: Park)

<u>Unit 5</u>: Diagnostic Medical Imaging 3hrs

Principle of Medical imaging techniques like X-Ray of Bone fracture, PET, MRI and CT Scan *(Chapter 24: Prakash, G.)*

Practical [Credits: 2]

1. ABO blood group typing.
2. Estimation of haemoglobin content using Sahli's haemoglobinometer.
3. Analysis of urine for abnormal constituents.
4. Total leucocytes count from blood.
5. Measurement of blood pressure under normal and stress condition.
6. Estimation of blood glucose/cholesterol by kit.
7. Determination of bleeding time/clotting time
8. Detecting defects of colour vision by Ishihara Charts.
9. Interpretation of ECG.
10. Medical Imaging techniques: X-Ray of bone fracture, MRI, CT scan.

Teaching and Learning Process:

Different instructing strategies shall be adopted including: Lectures, interactive lectures, classroom discussions and practical based on theory papers by analyzing body fluids, tissues, blood typing, chemical analyses, cell counts of human body etc. Use of digital technologies will enable students to get a better understanding of the concepts. Hands-on experience, including diagnostic analysis in the diagnostic laboratory and student presentations will provide supplement to conventional text books. Field studies will include visits to diagnostic laboratory or a visit to a hospital having diagnostic facilities.

Assessment Methods:

- Closed-book tests to evaluate the students' knowledge and understanding of material covered in the class.
- Internal evaluation based on the experiment performed during the internal examination or class tests conducted by the internal examiners.
- Dimension of comprehension and capacity to respond to inquiries as a piece of *viva-voce*.
- Involvement in class and group discussions of individual research and contribution to fruitful discussions.
- Assignments based on the text prescribed in the syllabus.
- Power Point presentation on any aspect of medical diagnostics.
- Hospital visit/medical institute visit.
- Project work (Students should execute one project of their choice or teacher may assign the project. Project report should be scanned for plagiarism through freely available software and a soft copy of the report should be mandatory).

Keywords:

Diagnostic methods, Infectious and Non-infectious diseases, Imaging techniques

Recommended Books:

- Park, K. (2007) Preventive and Social Medicine, B.B. Publishers
- Godkar P.B. and Godkar D.P. (2005) Textbook of Medical Laboratory Technology, III Edition, Bhalani Publishing House
- Prakash, G. (2012), Lab Manual on Blood Analysis and Medical Diagnostics, S. Chand and Co. Ltd.

Suggested Readings:

- Cheesbrough M., A Laboratory Manual for Rural Tropical Hospitals, A Basis For Training Courses
- Guyton A.C. and Hall J.E. Textbook of Medical Physiology, Saunders
- Robbins and Cortan, Pathologic Basis of Disease, VIII Edition, Saunders

Online Tools and Web Resources:

- https://www.skillstat.com/tools/ecg-simulator
- https://www.youtube.com/watch?v=ZoGfQM5JCnI
- https://www.youtube.com/watch?v=Qbnz4_qed9Q&t=276s
- https://www.youtube.com/watch?v=djAxjtN_7VE
- https://www.youtube.com/watch?v=9SUHgtREWQc&t=188s
- https://www.youtube.com/watch?v=fHUzVqoDnts

ZH SEC-IV: Research Methodology

Course Learning Objective:

This course offers overview of Research Methodology including quantitative and qualitative research in basic as well as applied aspects of Biological Sciences. It is designed to provide hands-on experience with collection, analysis and interpretation of data and also writing a report/thesis. Moreover, this course focusses on developing the skills necessary for pursuing a career in research. The students will be motivated to learn scientific investigation to solve problems, test hypothesis, develop or invent new products for the benefit of society.

Course Learning Outcome:

After completing this course, the students should be able to:

- Describe basic concepts of research and its methodologies
- Identify appropriate research topics and set up hypothesis
- Perform literature review using library (print) and internet (online) resources
- Design experiments/surveys, collect data and represent data in tables/figures
- Analyze data with appropriate software tools, interpret results and draw conclusion
- Write scientific report/ review/ thesis and prepare seminar/ conference presentations - oral as well as poster
- Understand the methods of citation and referencing styles, check plagiarism and get insight of intellectual property right

Course Content:

Theory [Credits: 2] 30 hrs

Unit1: Foundations of Research 4 hrs

Meaning, Objectives, Motivation: Research Methods *vs* Methodology, Types of Research: Analytical *vs* Descriptive, Quantitative *vs* Qualitative, Basic *vs*Applied.

(Chapter 1 and 2: Kothari; Chapter 1and 2: Walliman)

Unit 2: Research Design 8 hrs

Need for research design: Features of good design, Important concepts related to good design-Observation and Facts, Prediction and Explanation, Development of Models. Developing a research plan: Problem identification, Experimentation, Determining experimental and sample designs

(Chapter 3 and 4: Kothari; Chapter 3 and 4: Walliman)

Unit 3: Data Collection, Analysis and Report Writing 12 hrs

Observation and Collection of Data-Methods of data collection- Sampling Methods, Data Processing and Analysis Strategies;Preparation of Tables and Figures; Technical Reports and Thesis writing; Bibliography/References; Data Presentation using digital tools. Seminar presentation (oral/poster)

(Chapter 6, 7 and 14: Kothari Chapter 7, 8, 9 and 10: Walliman)

Unit 4: Ethical Issues 6 hrs

Intellectual Property Rights, Copy Right, Royalty, Patent laws, Commercialization, Plagiarism, Citations, Acknowledgement, Research Grants/ Fellowships

(Chapter 4: Walliman)

Practical [Credits: 2]

1. Usage of search engine tools for retrieving research/review papers
2. To generate a hypothesis and design an experiment
3. Collection of data, interpretation and writing a report
4. Graphical representation and interpretation of the data provided
5. Title and abstract writing for a given research paper
6. Preparation of bibliography in different formats as per journal requirements
7. Usage of software tools for checking plagiarism
8. Visit to Research Laboratory and/or Research Internship

Teaching and Learning Process:

Survey based data collection, graphical representation of data and compilation of report as assignments will be stressed upon. Visit to Research Laboratories will be organized to introduce and encourage usage of instruments and techniques by students. Participation in research internships/conferences/seminars will be encouraged to inculcate research skills.

Assessment Methods:

The students will be assessed on the basis of their performance in class room presentations as well as semester end examination.

Keywords:

Research methodology, Data analysis, Experimental design, Sampling, Research paper, Abstracts, Dissertation, Thesis, Citation, IPR, Plagiarism, Patent, Research grants, Fellowships

Recommended Books:

- Anthony, M, Graziano, A.M. and Raulin, M.L. (2009) Research Methods: A Process of Inquiry, Allyn and Bacon.
- Walliman, N. (2011) Research Methods- The Basics. Taylor and Francis, London, New York, USA.

Suggested Readings:

- Wadhera, B.L. (2002) Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, Universal Law publishing
- Kothari, C.R. (2009) Research Methodology, New Age International.
- Coley, S.M. and Scheinberg, C.A. (1990) "Proposal writing". Stage Publications.

Online Tools and Web Resources:

- https://swayam.gov.in/course/292-introduction-to-research
- https://explorable.com/research-methodology
- https://www.coursera.org/learn/research-methods
- https://www.coursera.org/learn/sciwrite

ZH SEC-V Sericulture

Course Learning Objective:

The course will make the students aware about the significance of sericulture as a profit-making enterprise. It will help the students to understand the biology of silkworms and its nutritional requirement to secrete quality silk. The course would clarify the techniques of silkworm rearing, reeling of silk and various measures to be taken to maximize the benefits. It would also help the students to know about various uses of silk and develop entrepreneurial skills required for self-employment in sericulture and silk production sector.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Learn about the history of sericulture and silk route.
- Recognize various species of silk moths in India, and exotic and indigenous races.
- Be aware about the opportunities and employment in sericulture industry- in public, private and government sector.
- Gain thorough knowledge about the techniques involved in silkworm rearing and silk reeling.
- Develop entrepreneurial skills necessary for self-employment in mulberry and seed production and be apprised about practicing sericulture as a profit-making enterprise.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Course Content:

Theory [Credits: 2] 30 hrs

Unit 1: Introduction 4 hrs

Sericulture: Definition, history and present status; Silk route; Types of silkworms, Distribution and races; Exotic and indigenous; Mulberry sericulture; Non-mulberry Sericulture, Eri, Muga, Tassar

(Chapter 3, Section 3.1: Manual on Sericulture
http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf)

Unit 2: Biology of Silkworm 3 hrs

Life cycle of *Bombyx mori;* Structure of silk gland and secretion of silk; Composition and properties of silk

(Chapter 3, Section 3.1: Manual on Sericulture
http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf)

Unit 3: Rearing of Silkworms 14 hrs

Selection of mulberry variety and establishment of mulberry garden, Rearing house and rearing appliances, Disinfectants: Formalin, bleaching powder, RKO Silkworm rearing technology: Early age and Late age rearing, Types of mountages, Harvesting and storage of cocoons, Post-harvest technology- Silk reeling, Dyeing and weaving, Ahimsa silk

(Chapter 3, Section 3.3, 3.4, 3.5 and 3.6: Manual on Sericulture
http://agritech.tnau.ac.in/sericulture/seri_silkworm4_lateage%20rearing.html)

<u>Unit 4</u>: Pests and Diseases 4 hrs

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates; Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial; Control and prevention of pests and diseases
(Chapter 4, Section 3.1: Manual on Sericulture
http://silks.csb.gov.in/coochbehar/wp-content/themes/common_district/coochbehar/dpm-frame2.html
http://agritech.tnau.ac.in/sericulture/disese%20mgt_silkworm.html)

<u>Unit 5</u>: Silk Industry and Its Importance 2 hrs

Silk usage and application in Textile and non-textile industry
(Sericulture:http://csb.gov.in/silk-sericulture/sericulture/
http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf)

<u>Unit 6</u>: Entrepreneurship in Sericulture 3 hrs

Prospects of Sericulture in India: Sericulture industry in different states, Employment opportunities in mulberry and non-mulberry sericulture sector, Economics in small scale and large-scale silk worm rearing, Scope for women entrepreneurs in sericulture sector
(*http://csb.gov.in/services/training/entrepreneurship/*
http://ministryoftextiles.gov.in/sites/default/files/note-on-sericulture-English-Jan2019.pdf
http://www.researchjournal.co.in/upload/assignments/5_188-190.pdf)

Practical [Credits: 2]

1. Study of the life cycle of different species of silk moths - *Bombyx mori, Philosamia ricini, Antherea paphia/Antherea mylitta, Antherea assama* and silk secreted by them.
2. Study of the sexual dimorphism in caterpillar, pupae and adults of *Bombyx mori.*
3. Study of the structure of silk gland of mulberry silk worms.
4. Study of rearing house and different appliances used in rearing of mulberry silk worms.
5. Study of the different disinfectants used in silkworm rearing houses.
6. Study of different types of mountages from specimen/photographs.
7. Analysis of silk fibre quality- Visual examination, thickness, purity.
8. Study of the parasites and predators of silk worms and their control- Uzi fly, Dermestid beetle, Vertebrates.
9. Study of silkworm diseases and their control- Pebrine, Flacherie, Grasserie, Muscardine.
10. Submission of a report on visit to a ‘Sericulture Institute’/‘Various Sericulture Centres in India’.

Teaching and Learning Process:

Information and concepts about benefits of silkworms in human life and how these benefits can be reaped, will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of silkworms in nature and study of rearing technology will be assisted through visits to various sericulture institutes, which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs. Blended learning including chalk-n-talk method and e-learning will be encouraged to make students’ learning more dynamic. Enquiry-based collaborative learning through presentations, debates, group discussions, and roundtables on the various aspects of silkworm biology will be promoted, to not only ensure effective learning and understanding of the concepts, but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware about handling of worms and their rearing methods. Visit to various sericulture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:

Various measures adopted will be as follows.

- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones in which evaluation is held.
- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcomes will be held.
- Regular Presentations: Presentations by the students on a topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries.
- *Viva-voce: Viva-voce* is a critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of students learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

Keywords:

Cocoon, Disinfectant, Eri, Flacherie, Grasserie, Moriculture, Mountages, Muga, Mulberry, Muscardine, Pebrine, Rearing, Reeling, Sericulture, Silk moth, Tasar, Textile, Uzi fly, Weaving

Recommended Books:

Manual on Sericulture (1976); Food and Agriculture Organisation, Rome
Ullal, S.R. and Narasimhanna M.N. (1987) Handbook of Practical Sericulture; 3rd Edition, CSB, Bangalore

Suggested Readings:

Yonemura, M. and Rama Rao, N. (1951) A Handbook of Sericulture. I. Rearing of silk-worms. Government Branch Press, Mysore.
Ananthanarayanan, S. K. (2008) Silkworm Rearing. Daya Publishing House
Aruga, H. (1994). Principles of Sericulture. CRC Press
Sathe, T. V. and Jadhav, A. (2002) Sericulture and Pest Management. Daya Publishing House
Yup-Lian, L. (1991) Silkworm Diseases. Food and Agricultural Organization.

Online Tools and Web Resources:

- Silkworm crop protection (https://swayam.gov.in/courses/152-silkworm-crop-protection)
- Sericulture (http://csb.gov.in/silk-sericulture/sericulture/)
- http://csb.gov.in/publications/videos/
- http://www.fao.org/3/x2099e/x2099e02.htm

ZH SEC-VI Genetic Counselling

Course Learning Objective:

The course on Genetic counselling will introduce the basic concepts of inheritance patterns, genetic and genomic basis of traits. It will inculcate a holistic understanding about the genetic basis of a particular clinical disorder. Updated information regarding causative genes, disease diagnosis and available treatment options for several single gene and complex genetic disorders will be provided. Training will be imparted in genetic counselling skills, so that the students could participate in effective genetic counselling.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Get acquainted with the diseases caused by genetic abnormalities.
- Develop the basic understanding of counselling the individuals based on the deductive methods.
- Deal with the various social and ethical aspects in relation to genetic diseases inheritance and its predictability in a responsible manner.
- Collect data about the history of a disease in a family and arrange it into a pedigree.
- Be aware and competent of the legalities and national and international policies in the area.
- Understand their risk for developing a genetic disease and to make informed decisions.

Course Content:

Theory [Credits: 2] 30 hrs

<u>Unit 1</u>: Nucleic Acids 4 hrs

Overview of the structure of DNA and RNA; Replication, transcription and translation (in brief); Control of gene expression, DNA methylation and imprinting.

(Chapter 17: Campbell; Chapter 5 and 6: Gardner)

<u>Unit 2</u>: Chromosomes 4 hrs

Basics of human cytogenetic nomenclature; Chromosome identification; Various techniques of karyotyping; Autosomal and sex chromosomal abnormalities

(Chapter 4: Peter S. Harper; Chapter 18-19: Gardner)

<u>Unit 3</u>: Mendelian Genetics 6 hrs

Mendel's experiments- laws and their exceptions; Introduction to linkage and recombination; Autosomal and X-linked inheritances; Multifactorial, Mitochondrial and complex inheritance.

(Chapter 2: Peter S. Harper, Chapter 14: Campbell; Chapter 7: Gardner)

<u>Unit 4</u>: Genetics of Human diseases 8 hrs

Molecular genetics of Human disease; Genetic basis of various diseases like Sickle cell anaemia, PKU, Thalassemia, Alzheimer’s’, Diabetes, Hypertension, cardiovascular, Cancer; Pedigree analysis (Symbols, preparation and analysis); Prenatal diagnosis of genetic disorders

(Chapter 6 and 3: Peter S. Harper)

<u>Unit 5</u>: Genetic Counselling 8 hrs

History, Famous Case Studies, Theory and Practice; Psycho-social aspects for the individual and the family in connection with genetic investigations; Legal aspects related to genetics,

Medical termination of pregnancy act, PC-PNDT act and other aspects of medical jurisprudence.
(Chapter 8, 9 and 10: Peter S. Harper; Chapter 15: V. P. Singh)

Practical [Credits: 2]

1. Introduction to genetic testing and its types, pre and post test counselling and evaluation.
2. Recording of family and personal history, Pedigree construction and prediction of genetic traits
3. Analysis for Mendelian diseases and Multifactorial disorders.
4. Case Studies- Any three popular ones.
5. Colour vision deficiency test using Ishihara cards.
6. PTC Test- The genetics of bitter taste.

Teaching and Learning Process:

Interactive teaching using: Power Point Presentations, Audio visual aids, Group discussions and Project work/case studies will be held.

Assessment Methods:

- Diagnostic assessment- to check the knowledge base.
- Formative assessment- written test/*viva voce* to check the retention of the topic.
- At the end summative assessment could be done and students to be rewarded on the basis. of presentations, test, project reports theory and practical examination.

Keywords:

Genetic Counselling, Gene, Chromosome, Karyotype, Inheritance, Autosomal, Sex-Linked, Disorder, Pedigree.

Recommended Books:

- Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008) Principles of Genetics. VIII Edition. Wiley India
- Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece, Neil A. Campbell (2016) Campbell's Biology (2016) Xi edition, Pearson's Education
- Harper, Peter S. (2010) Practical Genetic Counselling VII Edition; London, Hodder Arnold
- Singh, V.P. (2016) Legal Issues In Medical Practice: Medicolegal Guidelines For Safe Practice

Suggested Readings:

- Klug, W.S., Cummings, M.R., Spencer, C.A. (2012) Concepts of Genetics. X Edition, Benjamin Cummings
- Uhlmann W R., Jane L. Schuette, B. Yashar (2009). A Guide to Genetic Counselling

Online Tools and Web Resources:

- https://swayam.gov.in/courses/4922-genetics-and-genomics
- https://swayam.gov.in/course/96-genetics
- https://www.coursera.org/learn/genetics-evolution
- https://onlinelearning.hms.harvard.edu/hmx/courses/hmx-genetics/

- ## ZH SEC-VII Environmental Audit

Course Learning Objective:

An environmental audit is defined as a systematic, documented verification process of objectively obtaining and evaluating audit evidence to determine, whether specified environmental activities, events, conditions, management systems, or information about these matters conform with audit criteria, and communicating the results of this process. The International Chamber of Commerce defines environmental auditing as “a management tool comprising a systematic documented, periodic and objective evaluation of how well environmental organization, management and equipment are performing, with the aim of contributing to safeguarding the environment by facilitating management control of environmental practices.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- To provide understanding by the students of general chronology of audit, audit strategy, audit program and audit procedures;
- To provide comprehensive idea to the students on the ethical principles of audit profession;
- To develop an appropriate documentation for an environmental impact statement and to introduce the types of audit reports.
- To understand how the environmental commitments by industry can be monitored and audited
- how potential environmental impacts are described in Environmental Impact Assessments (EIA)
- how industry controls their environmental impacts through Environmental Management Systems (EMS)
- how environmental management systems are audited
- how waste is generated and controlled and other environmental management initiatives such as product life cycle analysis and sustainability programmes
- develop ability to plan, execute and document the environmental audit.
- develop entrepreneurial skills

Course Content:

Theory [2 Credits] 30 hrs

<u>**Unit 1:**</u> **Understanding Pollution** 10 hrs

Definition; pollution, Air Pollution: Air pollutants- Sources, primary and secondary pollutants and particulate matter, HAPs (hazardous air pollutants), Indoor pollution- different sources. Water Pollution: Sources- direct and indirect, impact of pollution on water bodies groundwater pollution – sources and effects. Wastes: Source, characteristics, types, and fate of solid wastes. Metal pollution: Metals in soil, food and water, elementary idea on metal pollution. Noise Pollution: General features, sources, noise classification, effects of sound pollution. Radiation Pollution: Man-made radiation, radiation hazards, nuclear accidents. Pesticide Pollution: Definition; sources, categories, pesticides in water and effects; elementary idea on IPM. Soil Pollution: Sources, types, effects of soil pollution
(Chapter 1, 2, 3, 4: Liu, Zhang, Liu; Chapter 9: Vasudevan)

<u>Unit 2:</u> Protection of Environment 7 hrs

International concerns and efforts for environmental protection; role of United Nations; Stockholm summit; priority issues; Rio Summit: Sustainable development; Earth day; Environment day; Ecotourism

(Chapter 9: Vasudevan; Chapter 1: Barrow; CPCB Report)

<u>Unit 3:</u> Environmental Audit 13 hrs

Introduction: Definition; types of auditing, Features of Effective Auditing, Programme planning and organization of Auditing Programme, Pre-visit data collection, Auditing Protocol, Onsite Audit; Data Sampling; Inspection, Evaluation and Presentation, Audit Report; Action plan, Management of Audit, Benefits of Environmental Audit, Environmental Audit Programme in India.

(Chapter 1, 13, 14, 15, 16, 17, 18: Srivastava)

Practical [Credits: 2]

1. Physico-chemical properties of polluted soils and water collected from various sites
2. Bacteriological sampling and analysis of environmental DNA (eDNA) from soil.
3. General principles of environmental audit.
4. Surveillance and quality of analysis of potable water.
5. Comparative analysis of various mega building projects and green belts, River valleys mining projects and its impact assessment
6. Case studies on effective utilization of environmental laws of ***any one***: oil refineries, electrical/electronic, fertilizer, petrochemical, pesticide or pharmaceutical industry. *(Chapter 19, 20: Srivastava)*

a) Questionnaires; b) Data Collection and Generation; c) Integration of Data and Analysis

Teaching-Learning Process:

The students will be able to give information and concepts about the benefits of environmental audits in industries and recognise environmental impacts resulting from industrial activity. They will be taught how to how critically review an environmental management system. This will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through case studies will be assisted through visits to industries which will create interest, enhance their understanding to prepare and perform a simple environmental audit and inculcate entrepreneurial skills among students.

Assessment Methods:

The assessment of students' achievement will be aligned with the course/program learning outcomes.

- Continuous evaluation of learning by diagnostic and formative evaluation should be followed.
- Efforts should be made to measure cognitive as well as applied learning.
- Project work, quiz, problem solving exercises, classroom assessment methods, closed-book and open-book tests, practical assignment, laboratory reports, seminar presentation, *viva voce* interviews, computerized adaptive testing, literature surveys and summative evaluations by end-semester examination *etc.* constitute the different components of the overall assessment.
- Moreover, students should be provided with feedback on their work with the aim of improving their academic performance.

Keywords:

Pollutants, Environment Protection and Management, Auditing, Environmental Audit Programme.

Recommended Books:

- Vasudevan, N. (2006) Essentials of Environmental Science. Narosa Publishing house, Delhi.
- Liu, J, Zhang, L, Liu, Z (2017) Environmental Pollution Control
- Srivastava, A.K. (2003) Environmental Auditing, A.P.H. Publishing Corporation, ISBN 81-7648-443-1,

Suggested Readings:

- CPCB (1997) "Pollution Control acts, Rules and Notifications issues there under "Pollution Control Series – PCL/2/1992, Central Pollution Control Board, Delhi,.
- Barrow, C.J. (2005) Environmental Management and Development, Taylor & Francis Group,
- Tiwari RK (2007) Global Environmental Policies. ABD Publishers

Online Tools and Web Resources:

- E-content on e-PG Pathshala portal of Government of Indiahttps://epgp.inflibnet.ac.in
- www.gpcb.gov.in
- www.cpcb.nic.in/National_Ambient_Air_Quality_Standards.php
- www.nptel.ac.in
- www.epa.gov/sustainability/basicinfo.htm 56 2.
- www.un.org/millenniumgoals/environ.shtml
- oee.nrcan.gc.ca/sites/oee.nrcan.gc.../energy-audit-manual-and-tool.pdf
- envfor.nic.in/division/introduction-8 5. cpcb.nic.in/
- envirocare.co.in/environmental-standards-in-india.htm

Acknowledgements

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List of Contributors and Reviewers

Course Type	Course Name	Contributors Name	Stakeholders' Feed-back
CC-I	Non-chordates I: Protista to Pseudocoelomates	Sarita Kumar Renu Gupta Anjali Priyadarshini Rita Rath Ragesh P.R.	C. L. Jonwal Pavitra Sharma Gauri Mishra Manoj Nimesh Anubha Das Vagisha Rawal
CC-II	Principles of Ecology	Ilmas Naqvi Parminder Kaur Jyoti Arora Ojit M.	Varunendra S. Rawat Anubha Das Sandhya Rai Nidhi Paliwal Meenakshi Thakur Arunima Sehgal Shivam Tyagi
CC-III	Non-chordates II: Coelomates	Sarita Kumar Renu Gupta Anjali Priyadarshini Rita Rath Ragesh P.R.	C. L. Jonwal Pavitra Sharma Gauri Mishra Manoj Nimesh Anubha Das Vagisha Rawal
CC-IV	Cell Biology	Monika Sharma Parminder Kaur Shailly Anand	Debjani M. Dutta Ranjana Seth Soma M. Ghorai Sadhna Sharma Smita R. Choudhury Anubha Das Shanuja Beri Surender Kumar Sadhna Gupta Shivani Tyagi Anil K. Bali Deepika Yadav Neena Kumar Charu D. Rawat Jyoti Arora Gauri G. Dhingra Monika Sharma
CC-V	Diversity of Chordates	Lokesh C. Mishra Kanchan Batra Regina T.	Lokesh C. Mishra Kanchan Batra Regina T.
CC-VI	Physiology: Controlling and Coordinating system	Tanushri Saxena R. K. Sagar Nisha Vashishtha	Tanushri Saxena R. K. Sagar Anita Verma

		Smita Bhatia Kaveri Chakrabarty	B. Hareramadas Anita K. Verma Nisha Vashishtha Smita Bhatia Kaveri Chakrabarty
CC-VII	Fundamentals of Biochemistry	Anita K. Verma Seema Makhija Vandana K. Singh Amit Bhattacharya Shanuja Beri	Tanima Bose Anita K. Verma Seema Makhija Vandana K. Singh Amit Bhattacharya Shanuja Beri
CC-VIII	Comparative Anatomy of Vertebrates	Rajni Arora Ragesh P.R. Supriya Singh	Sadhna Gupta Priya Goel Bipin Aggarwal
CC-IX	Physiology: Life Sustaining Systems	Tanushri Saxena R. K. Sagar Nisha Vashishtha Smita Bhatia Kaveri Chakrabarty	Tanushri Saxena R. K. Sagar Anita Verma B. Hareramadas Anita K. Verma Nisha Vashishtha Smita Bhatia Kaveri Chakrabarty
CC-X	Biochemistry of Metabolic Processes	Anita K. Verma Seema Makhija Vandana K. Singh Amit Bhattacharya Shanuja Beri	Tanima Bose Anita K. Verma Seema Makhija Vandana K. Singh Amit Bhattacharya Shanuja Beri
CC-XI	Molecular Biology	I.K. Singh Kamal K. Gupta Poonam Sharma Charu D. Rawat Simranjeet Kaur	I.K. Singh Charu D. Rawat Simranjeet Kaur
CC-XII	Principles of Genetics	Sukanya Lal Kamal K. Gupta Neera Mehra Varunendra S. Rawat	Chitra Bhasin Anita Grover Sudhir Verma Neetu Kukreja Charu D. Rawat Gauri G. Dhingra Brototi Roy Ritu Rai Richa Misra Pooja Arora Jeepinder Kaur Jasvinder Madhu Yashpal Kamal K. Gupta Neera Mehra Varunendra S. Rawat Sukanya Lal

CC-XIII	Developmental Biology	Anita Grover Varsha Baweja Rajni Arora Shilpa Bharti	Anita Grover Shilpa Bharti Sukanya Lal Smita R. Choodhury Brototi Roy Smita Bhatia Vandana K Singh Rajni Arora Varsha Baweja
CC-XIV	Evolutionary Biology	Arunima Sahgal Sudhir Verma Varunendra S. Rawat	Komal Kamra Arunima Sahgal Varunendra S. Rawat Sudhir Verma Anubha Das Sanjukta Das Jaspreet Kaur Simran jit Jasvinder Kaur
DSE-I	Animal Behavior and Chronobiology	Kamal K. Gupta Tenzin Ojit M. Anupam Varshney	Rita Rath Vertika Mathur Meenakshi Thakur Vatsala Dwivedi Shalu Singh Deepak Yadav Shovit Ranjan K.Cherita Devi
DSE-II	Animal Biotechnology	Neeraja Sood Rekha Kumari Deepika Yadav	Neeraja Sood Rekha Kumari Deepika Yadav Anita K. Verma
DSE-III	Basic of Neuroscience	B. Hareramadas Amarjyoti Jasvinder Kaur	B. Hareramadas Amarjyoti Jasvinder Kaur
DSE-IV	Biology of Insecta	Jeepinder J. Kaur S. K. Sagar Ragesh P.R.	Sarita Kumar Jeepinder J. Kaur Anita Verma S. K. Sagar Ragesh P.R.
DSE-V	Computational Biology	Sanjiv Mullick I.K. Singh Tarkeshwar Charu D. Rawat	Sanjiv Mullick I. K. Singh Tarkeshwar Charu D. Rawat
DSE-VI	Endocrinology	Brototi Roy Manisha Sengar Varsha Singh	Manisha Sengar Brototi Roy Varsha Singh Sunil Kumar
DSE-VII	Fish and Fisheries	Om Prakash R. Moses Luni	Om Prakash R. Moses Luni
DSE-VIII	Immunology	Hardeep Kaur	Sadhna Gupta

		I.K. Singh Sadhna Sharma	Rajni Arora Neeraja Sood Anita K. Verma Hardeep Kaur Sadhna Sharma Anju Jain I.K. Singh Gouri Nandy Ravi Toteja Rigzin Kang Smriti Sharma Poonam Sharma Meena Yadav Renu Solanki Dinesh Gautam
DSE-IX	Parasitology	Ojit M. Manish K. Sachdeva	Anita Verma Samar Pal Singh Beena Bhandari
DSE-X	Reproductive Biology	Smita Bhatia Sunil Kumar Meena Yadav Manisha A. Pandit	Kamal K. Gupta Brototi Roy Meena Yadav Sunil Kumar
DSE-XI	Wild Life Conservation and Management	Jyoti Arora Vartika Mathur Meenakshi Thakur	Vagisha Rawal Radhika Warikoo Neeti Pandey Sanjiv Mullick Vatsala Dwivedi Regina T.
GE-I	Animal Cell Biotechnology	Poonam Sharma Amitabh Mathur Chaitali Ghosh	Neeraja Sood Anil K. Bali Neera Mehra Rekha Kumari Gauri Dhingra Swati M. Biswas Neetu Bhattacharya Kuntal Kalra Anika Dua
GE-II	Animal Diversity	Manoj Nimesh Rakhi Gupta Kanchan Batra	Anita Verma Manoj Nimesh Rakhi Gupta Kanchan Batra
GE-III	Aquatic Biology	Om Prakash R. Moses Luni	Luni R. Moses Om Prakash
GE-IV	Environment and Public Health	Swati M. Biswas Jyoti Arora	Anil Bali Anjali Saxena Kanchan Srivastava Vineet Chitra Bhasin

GE-V	Exploring the Brain: Structure and Function	Amarjyoti Madhu Yashpal Shanuja Beri	B. Hareramadas Amarjyoti Madhu Yashpal Shanuja Beri
GE-VI	Food Nutrition and Health	Varsha Singh Rashmi Saini Kaveri Chakrabarty	Varsha Singh Rashmi Saini Kaveri Chakrabarty
GE-VII	Human Physiology	Renuka Gupta Archana Aggarwal Rachna Kapila	Anita Verma Sunil Kumar Renuka Gupta Archana Aggarwal Rachna Kapila
GE-VIII	Insect Vectors and Diseases	Jeepinder Kaur Anupam Varshney Sunita Yadav	Anita Verma Jeepinder Kaur Anupam Varshney Sunita Yadav
SEC-I	Apiculture	Rita Rath Sarita Kumar Anita Verma	Ragesh P.R. Pallee Shree K. Cherita Devi Radhika Warikoo
SEC-II	Aquarium Fish Keeping	Luni Om Prakash R. Moses	Luni R.Mosses K. Cherita Devi Samar Pal Om Prakash Jyoti Arora
SEC-III	Medical Diagnostics	Sunil Kayesth Neetu Bhattacharya Shilpa Bharti	Anupam Varshney Varsha Singh
SEC-IV	Research Methodology	Sanjiv Mullick Rashmi Saini Anita K. Verma	Sanjiv Mullick Rashmi Saini Anita K. Verma
SEC-V	Sericulture	Sarita Kumar Rita Rath Anita Verma	Anita Verma Sarita Kumar Palle Shree K.Cherita Devi Radhika Warikoo
SEC-VI	Genetic Counseling	Renuka Gupta R. Kapila Archana Aggarwal	B.K. Thelma Sudhir Verma Anju Shrivastava Rajnish Dwivedi Vinay Krishna
SEC-VII	Environmental Audit	Anita K. Verma Sarita Kumar Anita Verma Sudhir Verma Sunil Kumar	Sarita Kumar Anita Verma Anju Shrivastava Vandana K. Singh

दिल्ली विश्वविद्यालय
UNIVERSITY OF DELHI

Bachelor of Science (Hons) Biochemistry

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Academic Council

Date: 15th July 2019 No:

Executive Council

Date: 21st July 2019 No: E.C. (2) -20.07.2019

Applicable for students registered with Regular Colleges, Non Collegiate Women's Education Board and School of Open Learning

Syllabus

For

B.Sc. (Honours) Biochemistry
(Three Year Full Time Programme)

Under

Choice Based Credit System (CBCS)
Learning Outcome Based Curriculum Framework (LOCF)

(Syllabus applicable for students seeking admission in the B.Sc. (Hons) Biochemistry Course from the academic year 2019-20)

Department of Biochemistry
Faculty of Interdisciplinary and Applied Sciences
University of Delhi South Campus
New Delhi-110021

List of Contents

Page No.

PREAMBLE

Biochemistry is the branch of science that explores the chemical processes within and related to living organisms. It is a laboratory based science programme that brings together biology and chemistry and focuses on processes happening at the cellular and molecular level. Biochemistry is the study of the components and composition of living things and their assembly and interactions important in sustaining life. By using chemical knowledge and techniques, biochemists attempt to investigate and solve biological problems pertaining to the understanding of physiological processes, their malfunction leading to diseases and subsequent disease diagnostics, prevention, therapy and prognostics. Bachelor's degree in Biochemistry at University of Delhi endeavors to train students in this classical art of life sciences to create a knowledge pool and skilled manpower to take on the challenges that modern biological sciences poses in understanding the emerging dynamics of life processes and the myriads of diseases that threaten mankind.

Education in the 21st century has undergone a paradigm shift, which necessitates frequent updates in any curriculum to reflect the dynamic changes in knowledge outcome, more so for biological sciences where advances are rapid and far-reaching. The revised Choice-Based Credit System (CBCS) curriculum to be introduced in the academic session 2019-2020 conforms to Learning Outcome Based Curriculum Framework (LOCF) and aims at imparting concept based learning with emphasis on skill development and research.

For multi-faceted development of a student, the curriculum includes courses to gain specialization in biochemistry while at the same time obtain sufficient exposure to related and varied subjects and skills. The curriculum emphasizes on several "core" courses (C) that will train students with the basic as well as advanced concepts of the discipline of biochemistry. All students pursuing the Bachelor's degree with Honours shall study fourteen such core papers across the six semesters. Students pursuing the programme shall also study four Discipline-Specific Elective (DSE) courses in the fifth and sixth semesters, which they will select from a list of such courses based on their individual preferences. These DSE courses will include diverse papers in other areas of life sciences (like Microbiology and Plant Biochemistry) or specialized research oriented courses (like Molecular Basis of Infectious Diseases) or advanced courses of Biochemistry (like Advanced Cell Biology and Advanced Methodologies), which will provide students with wholesome knowledge and requisite skills preparing them for higher studies across the globe. The content of each paper (C and DSE papers) is based on the premise that the fundamental principles and ideas must come across in a clear, easy and concise manner. The course seeks to be diverse and yet will present the essence of biochemistry in a very elegant and focused manner that will build competitive edge not only for professional development in a related area but prepare students for academic pursuits like research and teaching.

The Skill Enhancement Courses (SEC), offered in the third and fourth semesters, emphasizes on hands-on-training and supplements the discipline courses in an appropriate manner to impart students the confidence and required skills in practical aspects of biochemistry to help them choose a future path in either industrial or academic setting. The

SEC courses also include a paper on research methodology that will prepare students appropriately for a future in research.

The Generic Elective Courses (GE) offer inter- and trans-disciplinary students an opportunity to obtain a flavour of Biochemistry in simple and concise terms. It will also help them to switch over to this discipline of study in the future, should they choose to do so. Students opting for these courses learn the basic concepts of Biochemistry right from the first semester onwards, with one paper in each of the first, second, third and fourth semester. . Students who join for Honours degree in Biochemistry will opt for Generic Elective courses from other related/unrelated disciplines.

Two value-based courses (Ability Enhancement Compulsory Courses - AECC) in the first and second semester will enable students to improve their knowledge and communication skills.

B.Sc. (Hons) Biochemistry

1. Introduction

Biochemistry is the branch of dynamic science that explores the chemical processes within living organisms/ systems. The study of Biochemistry aims to understand how all the molecules that constitute living organisms interact, to maintain and perpetuate life. It deals with the complexity of living organisms, the microscopic and macroscopic structures within organisms that have specific functions and their systems for extracting and transforming energy from the environment. Biochemistry also explains how organisms adapt to their changing environments and gradually evolve.

The teaching of such a dynamic and evolving course is best achieved through **Choice-based Credit System (CBCS)** since it offers opportunities to provide solid foundation in the core discipline, while allowing freedom to students to select discipline specific courses that augment the learning in core courses. This freedom is further reiterated through flexibility in opting courses that enhance specific skills in the discipline as well as selection of courses from other disciplines / departments that widen the scope for higher education and employability. The **Learning Outcome-based Curriculum Framework (LOCF)** built into the CBCS offers focus and purpose to the programme providing a platform for self-evaluation by students and teachers in addition to global assessment by all stakeholders. The combination of LOCF and CBCS also allows for lateral movement of students between institutes of higher learning and offers a level playing field for them across the nation.

1a. Nature and Extent of the B.Sc. (Honours) Programme in Biochemistry

Biochemistry is an interdisciplinary science with areas of overlap with Chemistry, Physics and Mathematics. It is a laboratory based science that acts as a bridge between Biology and Chemistry. It also shares boundaries with other interdisciplinary subjects such as Microbiology, Genetics and Biophysics. This course is designed so as to enable the students to gain theoretical knowledge and hands- on-experience in the laboratory. The course content is aimed at encouraging students to cultivate keen observational skills and to develop the ability to analyze and interpret experimental data, making them suitable for future careers in higher education and employment in industry and research institutes.

1b. Aims of the Programme

The overall objective of the Bachelors (Honours) Programme in Biochemistry is to enable students to learn and integrate foundational knowledge in Biology and Chemistry that is relevant to Biochemistry and thus prepare them for post-graduate education and /or careers as researchers in academia or related industries.

The program aims to:

- Provide students with scholarly experiences, both theoretical and hands-on, that help instil deep interests in learning the chemistry underlying the working of biological systems while developing broad and balanced knowledge and understanding of key biological concepts, principles and theories. The idea is to equip students with appropriate tools of analysis so that they can independently tackle issues and problems in the field of biology and chemistry.

- Encourage students to study the structure and function of specific molecules and pathways and their interactions and networking in biological systems with particular emphasis on regulation of chemical reactions in living cells.
- Develop in students an inquisitive learning approach to seek answers regarding the complex workings of various physiological systems, cellular multiplication and differentiation and communication within and between cells and organs, and the chemical bases of inheritance and disease.
- Empower students to apply the knowledge and skills they have acquired to the solution of specific theoretical and applied problems in Biochemistry.
- Build concepts in biochemistry that would enable them to undertake further studies in Biochemistry and related areas or in multidisciplinary areas and help develop a range of generic skills that are relevant to wage employment, self-employment and entrepreneurship.

1c. Program Duration, Design and Structure

Duration of the Program:

The BSc Biochemistry course is a three-year degree programme divided into six semesters. Each academic year (July - May) will consist of two semesters. Each semester will be of fifteen weeks duration with one week designated for teaching break to promote co-curricular and co-scholastic activities.

Program Design:

The program has been designed to offer a variety of discipline specific and interdisciplinary courses disseminated through class-room, laboratory and out-of-classroom modes of teaching, monitored through a repertoire of assessment methods. The teaching-learning process will include theory classes of one hour duration and practical classes of two hour duration for every credit offered. The curriculum will be delivered through various methods including classical chalk and talk, power-point presentations, essay writing and quiz contests, audio and video tools, e-learning and e-content, virtual labs, field trips or educational tours, seminars by external experts, workshops and symposiums and class discussions and debates. The learning outcome will be assessed by direct and indirect methods comprising broadly of Internal Assessment or Continuous Evaluation and End-Semester Examination. The internal assessment will include mid-term written tests, multiple choice questions, home and class assignments, oral presentations (seminars), group tasks, class discussions and debates, essay and report writing. End-semester assessments will include written tests and practical examinations. Each theory paper will carry a maximum of 100 marks, with 25% marks allotted for internal assessment and 75% for end-semester examination. Each practical paper will carry a maximum of 50 marks including experimentation, viva-voce and practical notebook assessment.

***Structure of the Programme**:*

The programme is structured into a variety of courses with different credits, some mandatory while others elective. Broadly, the programme comprises of Core Courses (CC) and elective courses. The core courses are all mandatory courses. The elective courses are of three kinds: Discipline-Specific Elective (DSE), Skill Enhancement Course (SEC) and Generic Elective (GE). The programme also includes two compulsory Ability Enhancement Courses (AEC).

To successfully complete the program, a student must study fourteen Core Courses, four Discipline-Specific Electives, two Skill Enhancement Courses, four Generic Elective Courses and two compulsory Ability Enhancement Courses. The Core Courses, Discipline-Specific Electives and Generic Electives are six-credit courses. The Skill Enhancement Courses are four-credit courses while the Ability Enhancement Courses are two credit-courses. A student has to earn a minimum of 148 credits to get a degree in B.Sc. (H) Biochemistry.

The six-credit courses will include theory classes of four credits each and practicals of two credits each. The four-credit courses will comprise of two-credit theory classes and two-credit practical courses. However, the two-credit courses will include only theory classes. One credit is equivalent to one-hour lecture per week for theory classes and two-hour sessions for practical classes. Each batch of students for practical sessions will be of fifteen members. If the number of students exceed fifteen (by at least ten), they will be divided into two equal batches.

It is mandatory for students to study two Core Courses each in Semesters I and II, three Core Courses each in Semesters III and IV, and two Core Courses each in Semesters V and VI. The Core Courses will be of six credits each (four credits theory and two credits practicals).

Six courses of Discipline-Specific Electives (DSE) are offered in the programme, of which students will opt any two in each of the Semesters V and VI. The DSE courses will be of six credits each (four credits theory and two credits practicals). A particular DSE course will be offered only if the minimum number of students opting for that course is 10.

Generic Elective (GE) courses for the programme will be offered by other departments of the respective college. Students will elect one GE course each in Semesters I, II, III, and IV. The GE courses will be of six credits each (four credits theory and two credits practicals). The Department of Biochemistry will offer seven GE courses for students of other departments in the respective colleges.

From a list of six Skill Enhancement (SE) courses provided, students will undertake two Skill Enhancement (SE) courses of four credits each in Semesters III and IV. The SE courses will be of four credits each (two credits theory and two credits practicals). The two compulsory Ability Enhancement Courses (AEC), AE1 (Environmental Sciences) and AE2 (English / MIL communication), will be of two credits each (theory only). Students will undertake one each in Semesters I and II.

2. Learning Outcome-based Approach to Curriculum Planning

The learning outcomes-based curriculum framework (LOCF) for a B.Sc. degree in Biochemistry is intended to provide a broad framework within which the biochemistry programme is designed such that it enables students to acquire a skill set that helps them understand and appreciate the field of biochemistry. The structure or design of this framework shall ensure a high standard of the Honours degree in Biochemistry in the University. It shall subsequently pave the way for periodic updation and review of the programme, all within the boundaries of the set framework. This programme specification, as outline in individual courses, is intended as a reference point for prospective students, current students, examiners and academic and support staff involved in delivering the programme and enabling student development and achievement.

Program learning outcomes are the central organizing features of student learning. They are developed from the complex interaction of a range of competing and complementary factors. Since program learning outcomes can only be achieved and demonstrated through component courses, course learning outcomes and their assessment are integrally related to program learning outcomes. The expected programme learning outcomes are described below while the course learning outcomes are included along with course contents. The LOCF in Biochemistry aims to achieve this important aspect of a modern teaching programme.

3. Characteristic Attributes of a Graduate in Biochemistry

A graduate in the Biochemistry programme is expected to demonstrate the following attributes:

- **Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, theoretical principles and experimental findings in Biochemistry and other related fields of study, including interdisciplinary subfields such as life science in general, medicine and clinical biology, plant sciences, biotechnology, microbiology, nutrition, forensics, bioinformatics and environmental science; (ii) ability to use modern instrumentation for chemical and physical analysis of biological samples.
- **Critical thinker and problem solver**: Ability to employ critical thinking and efficient problem solving skills in the various areas of biochemistry and related disciplines.
- **Sense of inquiry:** Biochemistry being the foundation for understanding all biological processes, a graduate in this discipline is expected to seek deeper knowledge by asking relevant/appropriate questions relating to issues and problems in the field of Biochemistry and related areas. It is also envisaged that the course will empower them with the ability to plan, execute and report the results of an experiment or investigation.
- **Research skills:** Capable of identifying a scientific problem, preparing/mobilising appropriate resources required for the project, and execute the project through to completion, while observing responsible and ethical scientific conduct; and biosafety and chemical hygiene regulations and practices.
- **Skilled communicator:** Ability to transmit complex technical information relating to biochemistry in a clear and concise manner in both oral and written formats.
- **Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory and in industry and field-based situations.
- **Digitally literate:** Capable of using computers for mining scientific information using modern library search tools from various open source platforms or journals and the ability to use technique specific software to conduct experiments and analyze data. The graduates are expected to be proficient in using computational & visualization tools to study bio-molecular structures, graphing and statistical software to analyze statistical significance of data and report data in the form of graphs, tables or figures.
- **Ethical awareness:** The graduates of this programme will be able to avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism. They will learn to appreciate environmental and sustainability issues and their societal relevance.

- **Lifelong learners:** Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and acquiring fresh skills.

4. Qualification Description

The qualification descriptors for B.Sc. (Honours) programme in Biochemistry include the following:

- A student should demonstrate (i) a comprehensive and coherent understanding of the field of Biochemistry, its applications and links to related disciplinary areas of study; (ii) practical knowledge that enables different types of professions related to the discipline, including research and development, teaching, entrepreneurship as well as industrial research abilities; (iii) skills in areas pertaining to current developments in the academic field of study, including a critical understanding of the latest developments in the field of Biochemistry and an ability to use established techniques of analysis.
- Demonstration of a comprehensive knowledge of study material, including current research articles, books and e-books relating to basic and advanced concepts.
- Demonstration of skills in collection of relevant data gathered by reading or experimentation and analysis and interpretation of the data using appropriate methodologies.
- Ability to communicate the results of studies undertaken in an academic field accurately in the form of a paper, oral presentation or report.
- Application of disciplinary knowledge and transferable skills to new or unfamiliar problems and issues and the ability to seek solutions to real-life problems.
- Imbibing the ability to function effectively either independently or as a constituent of a team.

5. Programme Learning Outcomes (PO)

The curriculum is designed to achieve the following outcomes:

PO1: Inculcate the basic concepts of biochemistry including an understanding of the fundamental biochemical principles and their applications in a systematic, methodical, scientific, evidence-based process. The programme will also provide a general understanding of the related disciplines with a holistic knowledge generation in biological sciences.
PO2: Develop problem solving and analytical skills through case studies, research papers and hands-on-experience, especially integrated into skill enhancement courses.
PO3: Students will gain proficiency in basic laboratory techniques and be able to apply the scientific method to the processes of experimentation, hypothesis testing, data interpretation and logical conclusions.
PO4*:* Provide requisite knowledge of laboratory safety, data replication and quality control, record keeping and other aspects of "responsible conduct of research".
PO5: Ability to employ modern library search tools to locate and retrieve primary literature on a topic and critically evaluate the literature.
PO6: Students will be able to apply and effectively communicate scientific reasoning and data analysis in both written and oral forms. They will be able to communicate effectively with

well-designed posters and slides in talks aimed at scientific audiences as well as the general public.
PO7: Students will learn to work collaboratively in a team.
PO8: Students will gain knowledge of ethical and good laboratory practices, health and biohazard regulations, plagiarism and intellectual property rights related issues practiced in modern era of scientific investigation.
PO9: Graduates will be able to apply the major theories and research procedures to contemporary societal issues.
P10: The programme will prepare students to plunge into various fields of higher education or related profession in various disciplines, armed with plethora of knowledge, hands-on-experience and scientific attitude, at national and global levels.

6. Teaching-learning processes

The foremost effort of teaching is to impart knowledge to students, factual as well as hypothetical. The manner in which this is communicated to the students determines the success of the teaching process. To be able to see tangible results, it is imperative that the teaching-learning process be bilateral. There are three critical components to the teaching learning process, namely content writing, content delivery and engaging the students to complete the course. A passive flow of information from the teacher to the taught should make way for a vibrant atmosphere of active participation from the students. Teachers participating in the programme would have a well-structured and well-planned lecture ready for the class that should compel the students to concentrate, understand and enjoy the discourse. Students would be encouraged to think independently and ask pertinent questions cultivating out-of-the-box thinking. The link between theory and practical would be made evident, as working with their hands reinforces the concepts first introduced in theory classes.

The traditional chalk and talk method of teaching is simple but very effective. Diagrams or additional material may be shown as slides but with minimum text-rich content. For concepts that are difficult to explain, power point presentations or videos would be used. Some laboratory experiments will be open ended. Students will be divided into small groups to encourage teamwork, healthy competition and to be able to complete the task in stipulated time frames. Students will be taken out of the classroom and into the world of research institutions as well as industries in the form of simple visits or internships or educational tours for maximum benefit. It will help them to correlate what they learn in the classroom with the real world. Additionally, teachers will use MOODLE platform to create lessons and interact with students to create an open and effective two-way communication channel. Digital initiatives such as the Swayam portal, National digital library and open education resources will be used to greatly facilitate blended learning and flipped class rooms encouraging students to be responsible for learning. Group discussions, debates and scientific talks by external experts will be arranged for facile learning. Students will be encouraged to write comprehensive reviews of papers in a particular topic, reports, essays and short projects to augment their writing skills. Students will also be motivated to deliver seminars to strengthen their oratory skills.

7. Assessment methods

Assessment methods are the strategies, techniques, tools and instruments for collecting information to determine the extent to which students demonstrate desired learning outcomes.

Student learning outcomes cannot be ascertained by single evaluation criteria. A combination of direct and indirect assessments would thus be used. Direct methods of assessment will be used for students to demonstrate their learning while indirect methods will be used to observe students reflect on their learning. Written tests, essays, quiz, presentations and seminars will be used as direct methods of assessment, and indirect methods will include surveys, discussions, debates, participation in scientific meetings and festivals. Embedded assessments, in other words "classroom-based" or "continuous" assessments will be utilized as both a grading instrument as well as data for assessing student learning outcomes. Some examples of assessment methods that will be used are given below:

Method	**Description**	**Direct or Indirect Assessment**
Attendance	Regular participation in class activities (Theory and Practicals)	Indirect
Observations	Information can be collected while observing "events" such as classes, group work, and study sessions.	Indirect
Performance	Students can be evaluated on participation in practicals, events, presentations, projects. Encourages public speaking skills.	Direct
Portfolio	Students' work is collected throughout the program which is assessed by faculty using a common scoring guide. Portfolios may contain assignments, reports, class tests, exams, case studies, presentations, practical file record etc.	Direct
Viva Voce or External Review	An interview conducted by external faculty to gauge the depth of theoretical knowledge, clarity, visualization and hands on practical skills of the student. Instills self-confidence to face interviews in their future careers.	Indirect
Internally developed class tests	These are shorter tests held periodically through the semester to assess how well the students have grasped the concepts and skills. Also encourages regular attendance.	Direct
Course Exam	A comprehensive written exam given near the end of every 2 semesters to determine a student's acquisition and application of a particular type of knowledge or skill, as well as the ability to integrate knowledge.	Direct

Structure of B.Sc. (Honours) Biochemistry under CBCS

Core Course

BCH C-1: Molecules of Life
BCH C-2: Cell Biology
BCH C-3: Proteins
BCH C-4: Enzymes
BCH C-5: Metabolism of Carbohydrates and Lipids
BCH C-6: Membrane Biology and Bioenergetics
BCH C-7: Hormone: Biochemistry and Function
BCH C-8: Human Physiology
BCH C-9: Gene Organization, Replication and Repair
BCH C-10: Metabolism of Amino Acids and Nucleotides
BCH C-11: Concepts in Genetics
BCH C-12: Gene Expression and Regulation
BCH C-13: Genetic Engineering and Biotechnology
BCH C-14: Immunology

Discipline Specific Elective (*Any four*)

BCH DSE-1: Nutritional Biochemistry
BCH DSE-2: Advanced Cell Biology
BCH DSE-3: Microbiology
BCH DSE-4: Molecular Basis of Infectious Diseases
BCH DSE-5: Plant Biochemistry
BCH DSE-6: Advanced Methodologies

Generic Elective (*Any four*)

BCH GE-1: Biomolecules
BCH GE-2: Techniques in Biochemistry
BCH GE-3: Proteins and Enzymes
BCH GE-4: Biochemical Correlation of Diseases
BCH GE-5: Intermediary Metabolism
BCH GE-6: Biochemical Applications in Forensics
BCH GE-7: Recombinant DNA Technology

Ability Enhancement Compulsory Course

AECC-1: English / MIL communication
AECC-2: Environmental science

Skill Enhancement Elective Course (*Any two*)

BCH SEC-1: Biochemical Techniques
BCH SEC-2: Biostatistics
BCH SEC-3: Research Methodology
BCH SEC-4: Bioinformatics
BCH SEC-5: Microbial Techniques

SEMESTER-WISE COURSE STRUCTURE of B.Sc. (Honours) Biochemistry

SEMESTER I		SEMESTER II	
C1	Molecules of Life	**C3**	Proteins
C2	Cell Biology	**C4**	Enzymes
AECC1	English/MIL Communication or EVS	**AECC2**	English/MIL Communication or EVS
GE-I	Generic Elective (*Any one*)	**GE-II**	Generic Elective (*Any one*)
	I. Biomolecules (GE-1)		I. Proteins and Enzymes (GE-3)
	II. Techniques in Biochemistry (GE-2)		II. Techniques in Biochemistry (GE-2A)
			III. Biochemical Correlation of Diseases (GE-4)
SEMESTER III		**SEMESTER IV**	
C5	Metabolism of Carbohydrates and Lipids	**C8**	Human Physiology
C6	Membrane Biology and Bioenergetics	**C9**	Gene Organization, Replication and Repair
C7	Hormone: Biochemistry and Function	**C10**	Metabolism of Amino Acids and Nucleotides
SEC-I	Skill Enhancement Course (*Any one*)	**SEC-II**	Skill Enhancement Course (*Any one*)
	I. Biochemical Techniques (SEC-1)		I. Bioinformatics (SEC-4)
	II. Biostatistics (SEC-2)		II. Microbial Techniques (SEC-5)
	III. Research Methodology (SEC-3)		III. Research Methodology (SEC-3A)
GE-III	Generic Elective (*Any one*)	**GE-IV**	Generic Elective (*Any one*)
	I. Intermediary Metabolism (GE-5)		I. Biochemical Correlation of Diseases (GE-4A)
	II. Proteins and Enzymes (GE-3A)		II. Recombinant DNA Technology (GE-7)
	III. Biochemical Applications in Forensics (GE-6)		III. Biochemical Applications in Forensics (GE-6A)
SEMESTER V		**SEMESTER VI**	
C11	Concepts in Genetics	**C13**	Genetic Engineering and Biotechnology
C12	Gene Expression and Regulation	**C14**	Immunology
DSE-I	Discipline Specific Elective (*Any two*)	**DSE-II**	Discipline Specific Elective (*Any two*)
	I. Nutritional Biochemistry (DSE-1)		I. Molecular Basis of Infectious Diseases (DSE-4)
	II. Advanced Cell Biology (DSE-2)		II. Plant Biochemistry (DSE-5)
	III. Microbiology (DSE-3)		III. Advanced Methodologies (DSE-6)

C: Core Courses (14); **GE**: Generic Elective (04); **AECC**: Ability Enhancement Compulsory Course (02); **SEC**: Skill Enhancement Courses (02); **DSE**: Discipline Specific Elective (04). **Numbers within bracket indicate the total number of courses offered in each category.**

Courses containing "A" in their course code are repeated in different semesters.

SCHEME FOR CHOICE BASED CREDIT SYSTEM IN B.Sc. HONOURS BIOCHEMISTRY

SEMESTER	COURSES OFFERED	COURSE NAME	CREDITS
I	Ability Enhancement Compulsory Course 1	English / MIL communication / Environmental Science	4
	Core course 1 Theory (C1)	Molecules of Life	4
	Core course 1 Practical	Molecules of Life	2
	Core course 2 Theory (C2)	Cell Biology	4
	Core course 2 Practical	Cell Biology	2
	Generic Elective 1 Theory (GE-1)	Biomolecules	4
	Generic Elective 1 Practical	Biomolecules	2
	Generic Elective 2 Theory (GE-2)	Techniques in Biochemistry	4
	Generic Elective 2 Practical	Technique in Biochemistry	2
II	Ability Enhancement Compulsory Course 2	English / MIL communication / Environmental Science	4
	Core course 3 Theory (C3)	Proteins	4
	Core course 3 Practical	Proteins	2
	Core course 4 Theory (C4)	Enzymes	4
	Core course 4 Practical	Enzymes	2
	Generic Elective 3 Theory (GE-3)	Proteins and Enzymes	4
	Generic Elective 3 Practical	Proteins and Enzymes	2
	Generic Elective 4 Theory (GE-4)	Biochemical Correlation of Diseases	4
	Generic Elective 4 Practical	Biochemical Correlation of Diseases	2
III	Core course 5 Theory (C5)	Metabolism of Carbohydrates and Lipids	4
	Core course 5 Practical	Metabolism of Carbohydrates and Lipids	2
	Core course 6 Theory (C6)	Membrane Biology and Bioenergetics	4
	Core course 6 Practical	Membrane Biology and Bioenergetics	2

	Core course 7 Theory (C7)	Hormone: Biochemistry and Function	4
	Core course 7 Practical	Hormone: Biochemistry and Function	2
	Skill Enhancement Course -1 Theory (SEC-1)	Biochemical Techniques	2
	Skill Enhancement Course -1 Practical	Biochemical Techniques	2
	Skill Enhancement Course -2 Theory (SEC-2)	Biostatistics	2
	Skill Enhancement Course -2 Practical	Biostatistics	2
	Skill Enhancement Course -3 Theory (SEC-3)	Research Methodology	2
	Skill Enhancement Course -3 Practical	Research Methodology	2
	Generic Elective – 5 Theory (GE-5)	Intermediary Metabolism	4
	Generic Elective – 5 Practical	Intermediary Metabolism	2
	Generic Elective – 6 Theory (GE-6)	Biochemical Applications in Forensics	4
	Generic Elective – 6 Practical	Biochemical Applications in Forensics	2
IV	Core course 8 Theory (C8)	Human Physiology	4
	Core course 8 Practical	Human Physiology	2
	Core course 9 Theory (C9)	Gene organization, replication and repair	4
	Core course 9 Practical	Gene organization, replication and repair	2
	Core course 10 Theory (C10)	Metabolism of Amino Acids and Nucleotides	4
	Core course 10 Practical	Metabolism of Amino Acids and Nucleotides	2
	Skill Enhancement Course – 4 Theory (SEC-4)	Bioinformatics	2
	Skill Enhancement Course – 4 Practical	Bioinformatics	2
	Skill Enhancement Course – 5 Theory (SEC-5)	Microbial Techniques	2
	Skill Enhancement Course – 5 Practical	Microbial Techniques	2

	Generic Elective – 7 Theory (GE-7)	Recombinant DNA Technology	4
	Generic Elective - 7 Practical	Recombinant DNA Technology	2
V	Core course 11 Theory (C11)	Concepts in Genetics	4
	Core course 11 Practical	Concepts in Genetics	2
	Core course 12 Theory (C12)	Gene expression and regulation	4
	Core course 12 Practical	Gene expression and regulation	2
	Discipline Specific Elective-1 Theory (DSE-1)	Nutritional Biochemistry	4
	Discipline Specific Elective-1 Practical	Nutritional Biochemistry	2
	Discipline Specific Elective-2 Theory (DSE-2)	Advanced Cell Biology	4
	Discipline Specific Elective – 2 Practical	Advanced Cell Biology	2
	Discipline Specific Elective – 3 Theory (DSE-3)	Microbiology	4
	Discipline Specific Elective – 3 Practical	Microbiology	2
VI	Core course 13 Theory (C13)	Genetic Engineering and Biotechnology	4
	Core course 13 Practical	Genetic Engineering and Biotechnology	2
	Core course 14 Theory (C14)	Immunology	4
	Core course 14 Practical	Immunology	2
	Discipline Specific Elective-4 Theory (DSE-4)	Molecular basis of infectious diseases	4
	Discipline Specific Elective-4 Practical	Molecular basis of infectious diseases	2
	Discipline Specific Elective-5 Theory (DSE-5)	Plant Biochemistry	4
	Discipline Specific Elective-5 Practical	Plant Biochemistry	2
	Discipline Specific Elective – 6 Theory (DSE-6)	Advanced Methodologies	4
	Discipline Specific Elective – 6 Practical	Advanced Methodologies	2

Total : 148 credits

Note: 1 Credit is equivalent to 1 hour of teaching per week for theory courses and 2 hour of teaching for practical courses.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE COURSES

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Molecules of Life (BCH C-1)
Semester - I

1. Course Objectives

The course aims to provide students with an understanding of biomolecules, the basic building blocks of living organisms, focusing on their structural underpinnings, unique properties, biological roles and functions and inter relations. The course will outline the importance of water as a biological solvent and vitamins as vital ingredients of life. Emphasis will be on the association between structure and function of various biomolecules at a chemical level with a biological perspective as well as hands on approach and laboratory techniques.

2.1 Course Learning Outcomes

On successful completion of the course students will be:

- Acquainted with chemical and molecular foundations of life and appreciate the role of water in biological systems.
- Able to comprehend the structure, function and acid base properties of amino acids.
- Introduced to the structure, properties and roles of carbohydrates, lipids and nucleic acids.
- Aware of the importance of vitamins in biological systems.
- Able to independently identify various biomolecules in the laboratory.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I : The foundations of biochemistry **No. of hours : 6**

Cellular and chemical foundations of life, Water: unique properties, weak interactions in aqueous systems, ionization of water, buffering action in biological system, water as a reactant and fitness of the aqueous environment.

UNIT II: Amino Acids **No. of hours : 8**

Structural features and classification; Physical properties, optical properties (Stereoisomerism); Chemical properties (acid base properties, titration curve) of amino acids; Uncommon amino acids and their functions

UNIT III: Carbohydrates and Glycobiology **No. of hours : 16**

Monosaccharides - structure of aldoses and ketoses; Ring structure of sugars, conformations of sugars, mutarotation, anomers, epimers and enantiomers; Structure of biologically important sugar derivatives, oxidation and reduction of sugars; Formation of disaccharides, reducing and non-reducing disaccharides; Polysaccharides – homo- and heteropolysaccharides, structural and storage polysaccharides; Structure and role of glycoconjugates - proteoglycans, glycoproteins and glycolipids (gangliosides and lipopolysaccharides); Carbohydrates as informational molecules.

UNIT IV: Lipids **No. of hours : 14**

Building blocks of lipids - fatty acids, glycerol, ceramide; Storage lipids - triacyl glycerol and waxes; Structural lipids in membranes – glycerophospholipids; Galactolipids and sulpholipids, etherlipids, sphingolipids and sterols, structure, distribution and role of membrane lipids. Plant steroids; Lipids as signals, cofactors and pigments. Qualitative tests for lipids.

UNIT V: Nucleic Acids **No. of hours : 10**

Nucleotides - structure and properties of bases, pentoses, nucleosides; Nucleic acid structure – Watson-Crick model of DNA, forms of DNA; Structure of major species of RNA - mRNA, tRNA and rRNA; Nucleic acid chemistry - UV absorption, effect of acid and alkali on DNA; Other functions of nucleotides - source of energy, component of coenzymes and second messengers.

Unit VI: Vitamins **No. of hours : 6**

Structure and active forms of water soluble and fat soluble vitamins; Deficiency diseases and symptoms, hypervitaminosis

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Safety measures in laboratories.
2. Preparation of normal and molar solutions.
3. Preparation of buffers, phosphate and acetate buffers.
4. Determination of pKa of acetic acid and glycine.
5. Qualitative tests for carbohydrates.
6. Qualitative tests for amino acids, proteins.
7. Qualitative tests for nucleic acids.
8. Separation of amino acids/ sugars/ bases by thin layer chromatography/paper chromatography.
9. Estimation of vitamin C.

2.3 References

1. Devlin, T.M. (2011). *Textbook of Biochemistry with Clinical Correlations* (7th ed.). New York, John Wiley & Sons, Inc. ISBN:978-0-470-28173-4.
2. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN: 13: 978-1-4641-2611-6 / ISBN:10:1-46412611-9.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Appreciation of the role of water in biological system.	Traditional chalk and board teaching and hands-on-experiments with buffers	Unit assessment by multiple choice questions (MCQ)
II.	Ability to comprehend the structure, function and acid base properties of amino acids.	Classroom teaching of structures and properties of amino acids and laboratory experiments on titration curves and identification of functional groups	Quiz on amino acid properties and structure. Students will be shown three-dimensional structures of amino acids in power points, which they will identify and relate to properties
III.	Introduction to the structure, properties and roles of carbohydrates.	Traditional chalk and board teaching; learning properties of carbohydrates through laboratory based identification	Test on structure and functions of carbohydrates
IV	Appreciation of the varied roles of lipids including distribution in different biological membranes	Traditional teaching of structures of lipids and video presentation of membrane lipids: learning structure and function of lipids and membranes through discussion and power point presentations	Test and MCQ on lipids
V.	Understanding nucleic acid chemistry and structure.	Chalk and board teaching and presentation on double helix model of nucleic acid structure.	Test and quiz on nucleic acids. Discussion on the history of discovery of double helix of DNA
VI.	Understanding of the biochemical importance of vitamins and their active forms	Classroom teaching of vitamin structures and their active forms and estimation of vitamin-C in laboratory	Quiz on vitamins, their active forms and deficiency diseases. Revision of the entire course

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Carbohydrates; Lipids; Nucleic acids; Amino acids; Vitamins; Water; Buffers

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Cell Biology (BCH C-2)
Semester I

1. Course Objectives

The objective of this paper is to offer insights into the basic structure and function of a cell and cellular organelles. The course also aims to impart understanding of cell cycle, cell death, cell renewal processes and various techniques of cell biology.

2.1 Course Learning Outcomes

The objective of this paper is to offer insights into the basic structure and function of a cell and cellular organelles. Students will:

- Learn about cell theory and basic cell structure
- Be introduced to cell fractionation and cell visualization techniques
- Gain knowledge about the structure and function of various cell organelles in a eukaryotic cell
- Acquire knowledge about the composition of cytoskeleton and extracellular matrix
- Acquire insight into cell division and cell death mechanisms

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to Cell Biology **No. of hours: 5**

Cell theory, Structure of prokaryotic and eukaryotic cell, exceptions to cell theory, mycoplasma, viruses, viroids, prions, cells as experimental models

UNIT II: Tools of Cell Biology **No. of hours: 10**

Cell Fractionation techniques: Principle of centrifugation, Sedimentation Coefficient, Differential and Density Gradient (isopycnic and rate zonal) centrifugation. Cell Visualization techniques: Principle of Light microscope, Phase Contrast microscope, Fluorescence microscope, Confocal microscope and Electron microscope; Sample preparation and staining techniques for different kinds of microscopy. Basic principles of identification of sub cellular organelles.

UNIT III: Cell Organelles (structure and function) **No. of hours: 17**

Nucleus: Structure of nuclear envelope, nuclear pore complex nucleolus and chromatin Endoplasmic Reticulum: RER - Brief overview of cotranslational and post-translational transport of proteins; SER – Lipid synthesis, brief overview of export of proteins from ER; Golgi apparatus: organization, brief overview of glycosylation of proteins within Golgi, lipid and polysaccharide metabolism in Golgi apparatus.

Lysosomes: Development of different forms of lysosomes, role in cellular digestion, lysosomal storage diseases Peroxisomes: assembly, functions (H_2O_2 metabolism, fatty acid oxidation), glyoxysomes Mitochondria: structure, endosymbiont theory, genome Chloroplast: structure, endosymbiont theory, genome

UNIT IV: Cell Wall, Extracellular Matrix and Cell Junctions No. of hours: 10

Prokaryotic and eukaryotic cell wall structure; ECM components – proteins, polysaccharides and adhesion molecules; basic concept of anchoring junctions, tight junctions and communication junctions (gap junctions and plasmodesmata)

UNIT V: Cytoskeleton No. of hours: 08

Structure, assembly and function of Microtubules: Axonemal and cytoplasmic microtubules (cilia, flagella, centrioles, basal bodies) Microfilaments: Actin and Myosin Intermediate Filaments: different classes. Role of cytoskeletal elements in the entry of infectious agents

UNIT VI: Cell Cycle, Cell Death and Cell Renewal No. of hours: 10

Eukaryotic Cell Cycle, Checkpoints, Cell Division (mitosis and meiosis); Brief overview of apoptosis and necrosis; Types and potency of Stem Cells, Cancer – types, salient features of a transformed cell, causes of cancer. Apoptotic death in relation to cell cycle

PRACTICALS

CREDIT : 2 TOTAL HOURS: 60

1. To study the parts of a microscope
2. Cytochemical staining of proteins by Methylene Blue
3. Cytochemical staining of RNA by Methyl Green Pyronin
4. Cytochemical staining of polysaccharides by PAS
5. To study different stages of mitosis by temporary preparation in onion root tip
6. To study different stages of meiosis by temporary preparation in onion flower buds/ grasshopper testes
7. To study cell organelles by using electron micrographs
8. To study the effect of isotonic, hypotonic and hypertonic solution on cells

2. References

1. Cooper, G.M., Hausman, R.E. (2013). *The Cell: A Molecular Approach* (6th ed.). Washington, DC: ASM Press & Sunderland, Sinauer Associates, MA. ISBN:978-0-87893-300-6.

Additional Resources:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Walter, P. (2008) *Molecular Biology of the Cell* (5th ed.). New York: Garland Science (Princeton). ISBN:0-8153-1619-4 / ISBN:0-8153-1620-8.
2. Karp, G. (2013). *Cell and Molecular Biology: Concepts and Experiments* (7th ed.). John Wiley and Sons. Inc. ISBN: 978-1-118-65322-7

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn about the cell theory and basics of cell structure	Milestones of the development in cell biology will be discussed, Models of cell structure will be shown	Students will be asked to research on this topic. Assignments will be conducted
II.	Students will be introduced to cell fractionation and cell visualization techniques	Students will be taught by use of video tutorial. They will be taken to various institutes for demonstration of some of the tools taught in class	Quiz will be organized. They will be shown various pictures to identify the various microscopy techniques. Assignment and tests.
III.	Students will gain knowledge about the structure and function of various cell organelles in a eukaryotic cell	Will be taught by chalk and board method. Students will be shown various power point presentations and videos for concept building	They will be asked to label various parts of organelles. Assignment and tests will be conducted.
IV.	Students will gain knowledge about the structure of cell wall, components of extracellular matrix and basics of cell junctions	Teaching will be imparted by chalk and board method and by videos.	Students will be assigned the task of retrieving information on the differences in cell wall in various kingdom of life and enlist the components of extracellular matrix.
V.	Students will acquire knowledge about the structure, composition and significance of cytoskeleton	Chalk and board method of teaching to be employed along with power point presentations and videos.	Students will be assigned the task of retrieving information on cytoskeleton elements and their relation to diseases
VI.	Students will acquire insight into cell division and cell death mechanisms	Power point presentations, video tutorials and traditional teaching will be utilized. Current research in this area will be discussed in groups	Assignment and tests; identification of different stages of cell division and cell death will be assigned

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Cell organelles, Cell wall, Cell-Cell Interactions, Cancerous Cells, Cell-Pathogen interactions, Cell Theory, Cell cycle, Transformed cell

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
<u>Proteins (BCH C-3)</u>
SEMESTER –II

1. Course Objectives

The course aims to introduce "proteins" and their importance to modern biochemistry, highlighting their structural features and unique characteristics that help them participate in every physiological process in life, thus also playing important role in disease manifestation and their interventions.

2.1 Course Learning Outcomes

After completion of the course, a student will

- Understand the diverse functions of proteins in a cell
- Understand the hierarchy of protein architecture – primary, secondary, tertiary & quaternary structure, with the ability to distinguish features of globular & fibrous proteins
- Be able to comprehend the fundamental mechanisms of protein folding and stability and their relation to conformational diseases
- Be able to describe and discuss the separation and purification techniques used in protein chemistry
- Learn to access and use the databases related to protein sequence and structure
- Understand specialized proteins like membrane proteins, defense proteins and motor proteins
- Gain comprehension of structure-function relationship of proteins and their significance in physiology, diseases and applications in industry and medicine.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to amino acids, peptides and proteins **No. of hours: 4**

Amino acids and their properties - hydrophobic, polar and charged. Multimeric proteins, Conjugated proteins and Metallo-proteins. Diversity of peptide and protein function and their applications. Solid phase peptide synthesis.

UNIT II: Hierarchy of protein structure **No. of hours: 18**

Organization of protein structure into primary, secondary, tertiary and quaternary structures. N-terminal and C-terminal amino acid analysis. Sequencing techniques - Edman degradation. Generation of overlap peptides using different enzymes and chemical reagents. Disulfide bonds and their location. Forces stabilizing the protein structure - covalent and non-covalent. Importance of primary structure in protein folding. The peptide bond, dihedral angles psi and phi, helices, sheets and turns, Ramachandran map. Motifs and domains. Structures of myoglobin and haemoglobin, α-keratin, silk fibroin, collagen.

UNIT III: Protein folding and conformational diseases **No. of hours: 6**

Denaturation and renaturation of Ribonuclease A – discovery of protein folding. Introduction to thermodynamics of folding and molten globule. Assisted folding by molecular chaperones, chaperonins and PDI. Defects in protein folding. Diseases associated with misfolding – Alzheimer's and Prion based.

UNIT IV: Specialized proteins **No. of hours: 10**

Transport protein: Haemoglobin - Oxygen binding curves, influence of 2,3-BPG, CO_2 and H^+, Hill plot, Cooperativity between subunits and models to explain the phenomena - concerted and sequential models. Haemoglobin disorders-sickle cell anemia, thalassemias. Motor proteins- Actin and myosin. Defense proteins- Antibodies, Membrane proteins- Integral and membrane associated proteins. Hydropathy plots to predict transmembrane domains.

UNIT V: Extraction, purification and characterization of proteins **No. of hours: 18**

Solubilization of proteins from their cellular and extracellular locations. Use of mechanical and chemical methods, homogenization, ultrasonication, French press and centrifugation. Ammonium sulphate fractionation, solvent fractionation, dialysis and lyophilization Ion-exchange chromatography, molecular sieve chromatography, hydrophobic interaction/reverse phase chromatography, affinity chromatography, HPLC and FPLC. Determination of purity, molecular weight, extinction coefficient and sedimentation coefficient. IEF, SDS-PAGE and 2-D gel electrophoresis.

UNIT VI: Introduction to Protein Databases **No. of hours: 4**

Introduction to protein sequence and structure databases (UNIPROT, SWISS-PROT & PDB), Protein sequence file Format (FASTA) and Visualization softwares.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Estimation of proteins using UV-absorbance and Biuret method.
2. Estimation of proteins using Lowry/Bradford method.
3. Determination of isoelectric pH of casein.
4. Ammonium sulphate fractionation of proteins.
5. Separation of proteins using anion-exchange chromatography (demonstration).
6. SDS-PAGE analysis of proteins (demonstration).
7. Molecular Visualization Softwares: Pymol and Rasmol for protein structures from PDB

2.3 References

1. Cooper, T.G. (2011). *The Tools of Biochemistry.* Wiley India Pvt. Ltd
2. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN13: 9781464126116, ISBN10: 1464126119

3. Schulz, G.E., Schirmer, R.H. (1979). *Principles of protein structure*. Springer, ISBN 978-1-4612-6137-7
4. Scopes, R.K. (1994) *Protein Purification. Principles and Practice* (3rd ed). Springer, ISBN 978-1-4737-2333-5
5. Stryer, L., Berg, J., Tymoczko, J., Gatto, G. (2019). *Biochemistry* (9th ed.). New York, WH: Freeman. ISBN-13: 9781319114671
6. Voet, D., Voet. J. G. (2013). *Biochemistry* (4th ed.). New Jersey, John Wiley & Sons Asia Pvt. Ltd. ISBN : 978-1-11809244-6.

Additional Resources

1. Whitford, D. (2004). *Protein Structure and function*. Southern Gate, Chichester, West Sussex: John Wiley & Sons, Inc. ISBN-13: 978-047149894 ISBN-10: 0471498947

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Appreciation of the significance of proteins in life; Understanding of the classification and diversity of functions of proteins; Knowledge of amino acids as building blocks of proteins, their classification and structures	Outlining history of development of proteins through power point presentations and landmark publications; Classification and diversity will be taught by chalk and board method; Stereochemistry models for amino acids structures and power point presentations and videos	Numerical problems related to codes in amino acids, numerical problems relating to the pKa and pI of amino acids.
II.	Knowledge of hierarchy of protein structures and various aspects of structures and sequencing methods; concepts of subunits with reference to hemoglobin structure	Traditional chalk and board method will be employed along with powerpoint presentations on 3D structures, Ramachandran Map and hierarchy of protein structures; Videos will be shown	Numerical problems on Sequencing will be assigned; Students will download 3D structures from PDB and visualize several aspects of structures using softwares.
III.	Basic concepts as to how proteins fold and what challenges they face during folding; Knowledge about chaperones that help in protein folding and diseases caused due to protein misfolding	Appropriate mix of chalk and board teaching as well as use of Power point presentations for clarity of concepts with images; Research papers will be discussed	Class presentations and case studies will help students understand misfolding diseases; They will be asked to match a few proteins with the diseases they cause due to misfolding. Each student will review a paper on the biotechnological

			importance of refolding of proteins *in vitro*
IV	Students will learn about the structural features and differences between fibrous and globular proteins with examples; Structural aspects of membrane proteins and their relation to function	Power point presentations; Chalk and board; Student interaction in class; Case studies with examples of each protein structural class	Images of proteins to identify globular and fibrous proteins will be provided. Transmembrane protein prediction tools will be used by students, Hydropathy plots will be discussed.
V.	Development of understanding of the rationale, basic principles, types of biochemical and biophysical methods for extraction and characterization of proteins	Chalk & board method of teaching followed by class discussions with examples.	Numerical methods to discuss enzyme activity, specific activity will assigned; Practical problems in protein purification will be discussed and assigned in groups
VI.	Students will learn about protein databases and tools available in public domain.	Power point presentations on various databases, protein sequence and structure retrieval to be utilized.	Assignments and quiz on databases and tools used in protein sequence and structure analysis; Students will be assigned the task of identifying new databases and tools by browsing papers and internet.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Amino acids, Peptides; Globular and Fibrous proteins; Protein structure; Denaturation and Renaturation; Purification of proteins; Protein Folding & Diseases; Protein Databases

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Enzymes (BCH C-4)
Semester - II

1. Course Objectives

The objective of the course is to provide detailed knowledge about enzymes, the biological catalysts with remarkable properties that sustain life, so as to develop an understanding of enzyme kinetics, mechanism of enzyme action and their regulation. The course also aims to outline the diverse applications of enzymes in disease diagnosis and therapy as well as in industry.

2.1 Course Learning Outcomes

- Students will learn the nature and importance of enzymes in living systems
- Students will gain insight into the thermodynamic and molecular basis of catalysis by enzymes and the underlying basis of their specificity
- Students will understand the mechanisms of enzyme action, kinetics of enzyme catalyzed reactions and clinical importance of enzyme inhibitors
- Students will also learn to appreciate how enzymes are regulated and the physiological importance of enzyme regulation in the cell
- The course will introduce students to the applications of enzymes in research and medicine as well as in industry, which will bolster their foray into industrial and biomedical research.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to enzymes and features of catalysis **No. of hours: 8**

General characteristics of enzymes; nature of enzymes - protein and non-protein (ribozymes – RNaseP, self-splicing introns, abzymes). Co-factor and prosthetic group, apoenzyme, holoenzyme. Classification and nomenclature of enzymes. Enzyme assays-discontinuous, continuous, coupled assays; Enzyme activity, specific activity, units to express enzyme activity. Features of enzyme catalysis, factors affecting the rate of chemical reactions, collision theory, activation energy and transition state theory. Catalysis, reaction rates and thermodynamics of reaction. Catalytic power and specificity of enzymes (concept of active site), Fischer's lock and key hypothesis, Koshland's induced fit hypothesis.

UNIT II: Enzyme kinetics **No. of hours: 12**

Relationship between initial velocity and substrate concentration, equilibrium constant, steady state kinetics, mono-substrate reactions. Michaelis-Menten equation, Lineweaver-Burk plot, Eadie-Hofstee and Hanes plot. Determination of K_M and V_{max}, K_{cat}, specificity constant. Effect of pH and temperature on the activity of enzymes. Types of bisubstrate reactions (sequential – ordered and random, ping pong reactions), examples. Differentiating bi-substrate mechanisms (diagnostic plots, isotope exchange).

UNIT III: Enzyme inhibition **No. of hours: 8**

Reversible inhibition (competitive, uncompetitive, non-competitive and mixed) and irreversible inhibition. Substrate inhibition. Structural analogs (allopurinol, methotrexate and trimethoprim). Mechanism based inhibitors (β-lactam antibiotics, difluoromethyl ornithine), clinical importance of enzyme inhibitors.

UNIT IV: Mechanism of action of enzymes **No. of hours: 12**

General features - proximity and orientation, strain and distortion, acid-base and covalent catalysis (chymotrypsin, lysozyme). Metal activated enzymes and metalloenzymes, transition state analogues. Coenzymes in enzyme catalyzed reactions. Structure, vitamin precursors, types of reaction involved in: TPP, FAD, NAD, pyridoxal phosphate, biotin, coenzyme A, tetrahydrofolate and lipoic acid.

UNIT V: Regulation of enzyme activity **No. of hours: 10**

Control of activities of single enzymes and metabolic pathways, feedback inhibition, allosteric modulation (aspartate transcarbamoylase), regulation by reversible covalent modification (glycogen phosphorylase and glycogen synthase). Proteolytic cleavage (zymogens- chymotrypsinogen, trypsinogen, procaspases). Regulation of multi-enzyme complex, properties (pyruvate dehydrogenase). Isoenzymes - properties and physiological significance (lactate dehydrogenase, hexokinase and glucokinase).

UNIT VI: Applications of enzymes **No. of hours: 10**

Enzymes as reagents (glucose oxidase, cholesterol oxidase);Marker enzymes in diagnostics (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases);Enzyme linked immunoassay (ALP and HRP);Enzyme therapy (streptokinase);Enzymes in research (Taq polymerase, restriction endonucleases). Immobilized enzymes and industrial applications of enzymes.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Partial purification of an enzyme using bulk methods or chromatography
2. Assay to determine activity and specific activity of an enzyme
3. Progress curve for an enzyme
4. Effect of pH/temperature on enzyme activity
5. Determination of K_M and V_{max} of an enzyme using Lineweaver-Burk plot
6. Calculation of inhibitory constant (K_i) for an enzyme
7. Continuous assay of an enzyme

2.3 References

1. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN: 13: 978-1-4641-2611-6 / ISBN:10:1-46412611-9.
2. Nicholas, C.P., Lewis, S. (1999). *Fundamentals of Enzymology* (3rd ed.). New York , Oxford University Press Inc. ISBN:0 19 850229 X.
3. Stryer, L., Berg, J., Tymoczko, J., Gatto, G. (2019). *Biochemistry* (9th ed.). New York, WH: Freeman. ISBN-13: 9781319114671

Additional Resources:

1. Voet, D., Voet. J. G. (2013). *Biochemistry* (4th ed.). New Jersey, John Wiley & Sons Asia Pvt. Ltd. ISBN : 978-1-11809244-6.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Knowledge about the basic properties and characteristics of enzymes and their action; insights into the factors affecting enzyme activity.	Historical perspectives; Power point presentations; Teaching using chalk and board method.	Oral questions will be asked in the class. Assignments to classify enzymes, determine specific activity and reaction rates.
II	Students will learn about the kinetics of enzyme catalyzed reactions and bisubstrate reactions	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class; Recent papers will be discussed	Class test will be conducted for internal assessment; Numerical problems assigned for enzyme kinetics.
III	Outline of the inhibitors of enzymes and their clinical importance.	Significance of inhibitors will be discussed with use of research papers; Classical chalk and board teaching and power point presentations	Various analytical problems will be assigned to students related to enzyme inhibition. Students will identify examples of inhibitors of various kinds.
IV	Understanding of the mechanism of enzyme action and the role of coenzymes in catalysis.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class	Demonstration by students with the help of models to test their understanding.

V	Students will learn how enzymes are regulated and the importance of enzyme regulation in the cellular context.	Teaching using chalk and board method along with power point presentations and video tutorials.	Problems will be assigned to test student's analytical ability. Class tests will be conducted for internal assessment. Students will discuss methods of regulation in groups.
VI	Detailed knowledge of the various applications of enzymes in medicine and research.	Teaching using chalk and board; Oral discussion sessions in the class; Videos. Special lecture will be arranged on current status of applications of enzymes	Assignment of a small project on identifying a specific application of any enzyme and tracings its development and current use.

(**Assessment tasks enlisted here are indicative in nature)

4. Keyword

Enzymes, Catalysis, Specific activity, Mechanism of action, Vitamins, Isoenzymes

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Metabolism of Carbohydrates and Lipids (BCH C-5)
Semester - III

1. Course Objective

The objective of this course is to provide an understanding of metabolism of carbohydrates and lipids, the enzymes involved in various metabolic pathways and regulation of metabolism in cells. The course also aims to outline the importance of such pathways in relation to metabolic defects.

2.1 Course Learning Outcomes

The learners will be able to:

- Understand the concepts of metabolism, characteristics of metabolic pathways and strategies used to study these pathways.
- Gain a detailed knowledge of various catabolic and anabolic pathways
- Understand the regulation of various pathways
- Gain knowledge about the diseases caused by defects in metabolism with emphasis on the metabolic control

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Glycolysis, and pentose phosphate pathway **No of hours: 12**

Autotrophs, Heterotrophs, catabolism, anabolism, metabolic pathways, ATP as energy currency, experimental approaches to study metabolism, High energy compounds. Glycolysis: overview, reactions, regulations including hormones, fates of pyruvate, feeder pathways for glycolysis, galactosemia. Lactose intolerance. Cori and Cori cycle. Pentose phosphate pathway and its importance, Relationship between glycolysis and pentose phosphate pathway. Anaerobic ATP production, fermentation.

UNIT II: Additional pathways in carbohydrate metabolism **No of hours: 12**

Glycogen synthesis, glycogen breakdown, regulation of glycogen metabolism, gluconeogenesis. Glycogen storage diseases; Von Gierke, Pompe, Cori and McArdle. Gluconeogenesis. Photosynthesis dark reaction: Calvin cycle, regulation, Photo respiration, C4 and CAM pathways in plants.

UNIT III: Citric acid cycle **No of hours: 10**

Overview of citric acid cycle, synthesis of acetyl Coenzyme A, enzymes of citric acid cycle, regulation of citric acid cycle, anaplerotic reactions, amphibolic nature, Malate aspartate shuttle, Glyceraldehyde-3-phosphate dehydrogenase shuttle, Glyoxylate cycle in plants. Signaling pathways, regulation of carbohydrate metabolism by hormones, diseases associated with metabolic irregularities.

UNIT IV: Degradation of lipids **No of hours: 10**

Lipid digestion, absorption and transport. Fatty acid oxidation: transport to mitochondria, activation of fatty acids, β oxidation of saturated, unsaturated, odd and even numbered and branched chain fatty acids, regulation of fatty acid oxidation, peroxisomal β oxidation, ω oxidation and α oxidation. Ketone-body metabolism.

UNIT V: Synthesis of lipids **No of hours: 10**

Transport of mitochondrial Acetyl Co A to cytosol, Fatty acid synthase complex enzyme. Synthesis of saturated, unsaturated, odd and even chain fatty acids, regulation of fatty acid metabolism. Synthesis of glycerophospholipids and sphingolipids. Cholesterol metabolism, diseases associated with abnormal lipid metabolism.

UNIT VI: Regulation of metabolism **No of hours: 06**

Well-fed state, early fasting state, fasting state, early re-fed state, energy requirements, reserves and caloric homeostasis.

PRACTICALS

CREDIT : 2 **TOTAL HOURS : 60**

1. Estimation of blood glucose in serum using ortho toluidine method/ GOD-PxD method
2. Sugar fermentation by microorganisms.
3. Assay of salivary amylase.
4. Isolation of lipids from egg yolk and separation by TLC.
5. Cholesterol estimation.

2.3 References

1. Devlin, T.M. (2011). *Textbook of Biochemistry with Clinical Correlations* (7th ed.). New York, John Wiley & Sons, Inc. ISBN:978-0-470-28173-4.
2. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN: 13: 978-1-4641-2611-6 / ISBN:10:1-46412611-9.
3. Voet, D., Voet. J. G. (2013). *Biochemistry* (4th ed.). New Jersey, John Wiley & Sons Asia Pvt. Ltd. ISBN:978-1-11809244-6.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn the concepts of metabolism with an emphasis on glycolysis and gluconeogenesis	Traditional chalk and black board method, Audio visual presentation. Class room discussion	Assignment, unit -test and practical assessment through experiment
II.	Students will learn about glycogen synthesis, breakdown, glycogen storage diseases, Calvin cycle C3 and C4 pathways in plants	Traditional chalk and black board method with examples and reactions and experiments	MCQ based assignments, unit –test and practical assessment through experiment
III.	The students will learn about overview, enzymes and regulation of citric acid cycle and glyoxylate cycle in plants. They will also learn about hormonal regulation of carbohydrate metabolism and diseases associated with metabolic irregularities.	Revision of the previous classes will be conducted. Traditional chalk and black board method, Audio visual presentation	Internal assessment tests will be conducted, – presentations will be assessed along with practical assessment
IV	The students will learn about lipid digestion, Fatty acid oxidation, and Ketone-body metabolism.	Chalk and board teaching along with presentations. Class discussions on syllabus topics will be performed.	Assessment through midterm examination and internal assessment test
V.	The students will learn about synthesis of saturated, unsaturated, odd and even chain fatty acids and regulation of fatty acid metabolism. They will also learn about the synthesis of	Presentations will be delivered along with traditional chalk board method. Class room revisions will be conducted before each class.	MCQ based internal assessment test will be held, quiz will be conducted and end term examination.

	glycerophospholipids and sphingolipids. Cholesterol metabolism, diseases associated with abnormal lipid metabolism		
VI.	The students will learn Well-fed state, early fasting state, fasting state, early re-fed state in metabolism.	Traditional chalk and black board method, students will be asked to deliver seminars to enhance their understanding and presentation skills.	End term examination evaluation, class room quiz will be held, unit - test and practical assessment through experiment.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Metabolism, Carbohydrates, Lipids, Glycolysis, Citric acid cycle, Allosteric regulation, Fatty acid oxidation, Ketone bodies, Starve feed cycle, Blood glucose regulation

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Membrane Biology and Bioenergetics (BCH C-6)
Semester III

1. Course Objective

The objective of the course is to provide students with the basic understanding of membrane composition, structure-function relationship and properties of membranes. The course will also provide an understanding of the various types of membrane transporters and their molecular mechanisms. The course will introduce students to the basic tenets of Bioenergetics and detail out the molecular mechanisms of oxidative phosphorylation and photophosphorylation.

2.1 Course Learning Outcomes

On successful completion of the course, students will:

- Understand the general composition and structure of biomembranes.
- Gain knowledge of the basic properties of membranes such as membrane fluidity.
- Have knowledge about the various types of membrane transport mechanisms.
- Understand the basic tenets of Bioenergetics.
- Be able to imbibe the concept of chemi-osmotic theory and the mechanism of oxidative phosphorylation and ATP synthesis.
- Understand the basic mechanisms of photophosphorylation in plants and microbes.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Membrane composition and structure **No. of hours: 12**

Historical background and various membrane models. Overview of membrane functions. Composition of membranes: Lipids -Phospholipids, Glycolipids, sterols; Proteins - Peripheral Proteins, Integral Membrane Proteins and Lipid-Anchored proteins, and carbohydrates. Comparison of the composition of various cellular and subcellular membranes. Lateral and transverse asymmetry in membranes. Role of Flippase, Floppase and Scramblase. Model systems to study membranes - Lipid Monolayers, Planar Bilayer and Liposome, and their application. Polymorphic Lipid-Water Systems. The various determinants of polymorphic phases: CMC, lipid shape, critical packing parameter.

UNIT II: Membrane dynamics **No. of hours: 8**

Membrane fluidity: lateral, transverse and rotational motion of lipids and proteins. Factors affecting membrane fluidity- composition, barriers (tight junctions), cytoskeleton interactions, microdomains – rafts, caveolae. Fence and gate model. Study of RBC membrane architecture. Homeoviscous Adaptation. Techniques to study membrane dynamics: FRAP, TNBS, SPT.

UNIT III: Membrane transport **No. of hours: 12**

Thermodynamics of transport. Simple diffusion and facilitated diffusion. Passive transport- glucose transporter and anion transporter. Primary active transporters- P type ATPases, V type ATPases, F type ATPases. Secondary active transporters - lactose permease, Na+ -glucose symporter. ABC family of transporters – MDR and CFTR. Group translocation and bacteriorhodopsin. Ion channels: voltage-gated ion channels (Na+ /K+ voltage-gated channel) and ligand-gated ion channels (acetyl choline receptor), and aquaporins. Ionophores: valinomycin, gramicidin. Relationship of membrane transport and diseases.

UNIT IV: Introduction to Bioenergetics **No. of hours: 8**

Laws of thermodynamics. Concept of state functions, free energy change, equilibrium constant, coupled reactions, energy charge, ATP cycle, phosphorylation potential, and phosphoryl group transfers. Chemical basis of high standard energy of hydrolysis of ATP, PEP, 1,3 BPG and thioesters. Redox reactions, standard redox potentials and Nernst equation. Universal electron carriers.

UNIT V: Oxidative phosphorylation **No. of hours: 10**

The electron transport chain - its organization and function. Peter Mitchell's chemiosmotic hypothesis and Proton motive force. F_oF_1 ATP synthase, structure and mechanism of ATP synthesis. Metabolite transporters in mitochondria. Regulation of oxidative phosphorylation. ROS production and antioxidant mechanisms. Thermogenesis Alternative respiratory pathways in plants.

UNIT VI: Photophosphorylation **No. of hours: 10**

General features of photophosphorylation, historical background and Hill's reaction. Role of photosynthetic pigments and light harvesting systems in plants and microbes. Bacterial photophosphorylation in purple bacteria and Green sulfur bacteria. Photophosphorylation in plants. Molecular architecture of Photosystem I and Photosystem II. The Z-scheme of photosynthetic electron flow. Cyclic photophosphorylation and its significance.

PRACTICALS

CREDIT: 2 **TOTAL HOURS: 60**

1. Effect of lipid composition on the permeability of a lipid monolayer.
2. Determination of CMC of detergents.
3. Preparation of RBC ghost cell.
4. Study the photosynthetic O_2 evolution in hydrilla plant.
5. Isolation of chloroplast from spinach leaves and estimation of chlorophyll content.
6. Study the Hill reaction by using artificial electron acceptor.
7. Separation of photosynthetic pigments by TLC.
8. Separation of RBC membrane proteins by SDS-PAGE.
9. Isolation of mitochondria from liver and assay of marker enzyme SDH.

2.3 References

1. Garret, R.H., Grisham, C.M. (2016). *Biochemistry* (6th ed.). Boston, Cengage Learning. ISBN-10: 1133106293, ISBN-13: 978-1133106296
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Scott, M.P. (2016). *Molecular Cell Biology* (8th ed.). New York, WH: Freeman & Company. ISBN-13: 978-1-4641-0981-2.
3. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN: 13: 978-1-4641-2611-6 / ISBN:10:1-6412611-9.
4. Voet, D.J., Voet, J.G., Pratt, C.W. (2008). *Principles of Biochemistry* (3rd ed.). New York, John Wiley & Sons, Inc. ISBN:13: 978-0470-23396-2

Additional Resources:

1. Wardhan, R., Mudgal, P. (2017). *Text Book on Membrane Biology* (1st ed.). Singapore, Springer. ISBN-10: 9811071004, ISBN-13: 978-9811071003

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Understand the general composition and structure of biomembranes. To study various membrane model systems and their application.	Traditional chalk & board method with powerpoint presentations. Students to do comparative study of various cellular and subcellular membranes.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture.
II.	Understand membrane fluidity, and various techniques used to study membrane fluidity.	Traditional chalk & board method with powerpoint presentations	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture.
III.	Have knowledge about the various types of membrane transport mechanisms.	Traditional chalk & board method with powerpoint presentations.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture. Mid-term exam.

IV	Understand the basic tenets of Bioenergetics.	Traditional chalk & board method with powerpoint presentations. Numerical problems relating to free energy change, entropy, etc., to be done in class to explain spontaneous, endothermic, exothermic reactions.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture.
V.	Understand the concept of chemiosmotic theory and the mechanism of Oxidative phosphorylation and ATP synthesis.	Traditional chalk & board method with powerpoint presentations. Numerical problems relating to standard redox potential, proton motive force done in class. Videos of rotational catalysis shown.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture.
VI.	Understand the basic mechanisms of photophosphorylation in plants and microbes.	Traditional chalk & board method with powerpoint presentations. Numerical problems relating to photophoshorylation efficiency done.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture. Power point presentation by students.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Membrane asymmetry, Membrane fluidity, ATPase, Ion channels, Ionophores, PMF, Oxidative phosphorylation, Photophosphorylation.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Hormone : Biochemistry and Function (BCH C-7)
Semester - III

1. Course Objectives

The course is designed to provide an understanding of the process of cellular communication including signal reception, transduction, amplification and response. The course will enable students to understand and appreciate the delicate network and balance of hormones required for the healthy functioning of the human body. It will provide an understanding of the different endocrine factors that regulate metabolism, growth, ionic homeostasis, glucose homeostasis and reproductive function. It outlines the consequences of hormonal imbalances with special emphasis on human diseases. The course will also prepare a student for postgraduate studies in any course related to molecular medicine.

2.1 Course Learning Outcomes

On successful completion of the course, a student will:

- Understand and appreciate the different cognate and non-cognate modes of communication between cells in a multi-cellular organism
- Understand the role of endocrine system in maintaining ionic and glucose homeostasis
- Be able to describe molecular, biochemical and physiological effects of all hormones and factors on cells and tissues.
- Understand the integrative communications that regulate, growth, appetite, metabolism and reproduction\
- Be prepared for interpreting clinical parameters in a real life situation

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to Endocrinology and Cellular signaling **No of hours: 17**

Functions of hormones and their regulation. Chemical signaling - endocrine, paracrine, autocrine, intracrine and neuroendocrine mechanisms. Chemical classification of hormones, transport of hormones in the circulation and their half-lives. Hormone therapy. General introduction to Endocrine methodology. Hormone receptors - extracellular and intracellular. Receptor - hormone binding, Scatchard analysis. G protein coupled receptors, G proteins, second messengers - cAMP, cGMP, IP3, DAG, Ca^{2+}, Effector systems - adenylyl cyclase, guanylyl cyclase, PDE, PLC. Protein kinases (PKA, PKB, PKC, PKG). Receptor tyrosine kinases - EGF, insulin and Ras - MAP kinase cascade. Non receptor tyrosine kinase-erythropoietin receptor JAK - STAT pathway. Steroid hormone Receptor. Receptor regulation and cross talk.

UNIT II: Hypothalamic- Hypophysial system: No. of hours: 5

Hypothalamic - Pituitary axis: anatomy, histology, vasculature and secretions. Physiological and biochemical actions of hypothalamic hormones and anterior pituitary hormones; Hormone feed- back regulatory cascade. Posterior pituitary hormones –structure, physiology and biochemical actions of AVP and Oxytocin; Diabetes insipidus.

UNIT III: Hormones regulating Metabolism, Calcium homeostasis and Growth: No. of hours: 14

Thyroid gland - Histology; Biosynthesis of thyroid hormone and its regulation: Role of TRH and TSH in T4 synthesis and response. Physiological and biochemical action of Thyroxine. Pathophysiology of thyroxine secretion: Hyper and hypothyroidism, Goiter, Graves' disease, Cretinism, Myxoedema.
Regulation of calcium homeostasis: PTH, Vitamin D and calcitonin. Mechanism of Ca^{2+} regulation and pathways involving bone, skin, liver, gut and kidneys. Pathophysiology - rickets, osteomalacia, osteoporosis.
Regulation of Growth: growth hormone and somatomedin, Endocrine disorders - gigantism, acromegaly, dwarfism, pygmies. Physiology and biochemical actions of Growth factors- EGF, PDGF and Erythropoietin.

UNIT IV: Hormones of the Adrenals: No. of hours: 8

Histology of Adrenal Gland. Physiology and action of Aldosterone; the Renin Angiotensin System. Physiology and Biochemical actions of Cortisol. Regulation of cortisol synthesis: POMC and CRH. Adrenal medullary Hormones: Epinephrine and Norepinephrine. The Fight or flight response; Dual receptor hypothesis. General adaptation syndrome: acute and chronic stress response. Pathophysiology – Addison's disease, Conn's syndrome, Cushing syndrome.

UNIT V: Pancreatic and GI Tract Hormones: No. of hours: 10

Cells involved in the release of gastrointestinal hormones; the gastrin family of hormones and CCK: the secretin family of hormones; Incretins; Ghrelin; Summary of hormone metabolite control of GI function. Hormones of the Pancreas: Structure, synthesis, physiology and biochemical actions of insulin and glucagon. Adipocyte hormones: Adiponectin and leptin; Appetite and satiety control. Pathophysiology - Type I and type II Diabetes mellitus.

UNIT VI: Reproductive Hormones: No. of hours: 6

Male and female sex hormones. Interplay of hormones during ovarian and uterine phases of menstrual cycle; Placental hormones; role of hormones during parturition and lactation. Hormone based contraception and hormone therapy.

PRACTICALS

CREDIT: 2 TOTAL HOURS : 60

1. Determination of oral Glucose tolerance test as a confirmatory test for Diabetes Mellitus.

2. Estimation of serum Ca^{2+}.
3. Estimation of serum T4
4. HCG based pregnancy detection test.
5. Estimation of serum electrolytes.
6. Case studies on hormone disorders.

2.3 References

1. Cooper, G.M., Hausman, R.E. (2009). The Cell: A Molecular Approach (5th ed.). Washington, DC: ASM Press & Sunderland, Sinauer Associates. ISBN:978-0-87893-300
2. Hadley, M.C., Levine, J.E. (2007). *Endocrinology* (6th ed.). New Delhi, Pearson Education, Inc. ISBN: 978-81-317-2610-5.
3. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN: 13: 978-1-4641-2611-6 / ISBN:10:1-46412611-9.
4. Widmaier, E.P., Raff, H., Strang, K.T. (2019). *Vander's Human Physiology* (15th ed.). USA, McGraw Hill International Publications. ISBN: 978-0-07-128366-3.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be introduced to hormones, various types of cellular signaling, classical and modern endocrine methodologies. They will understand the concept of signal, reception, transduction, amplification and response, Scatchard analysis, signal transduction and steroid receptors.	Teaching will be conducted both through black board mode and power point presentation mode.	Students will be given questions that are application based and require analytical skills. Quizzes will be held to gauge their conceptual understanding.
II.	They will also gain insight into significance of the hypothalamic pituitary axis, secretions of the hypothalamus, anterior and posterior pituitary, concept of hormonal feedback regulation.	Powerpoint presentations and black board and oral discussions will be used for teaching	Oral questions will be asked in the class. Students will be given to prepare power point presentation on the assigned topics related to the class teachings.
III.	Knowledge about the synthesis, structure and biochemical functions of the thyroid gland secretions, factors that monitor calcium homeostasis in the human	Classical chalk and board teaching, oral discussions and power point presentation whenever needed.	Students will be asked to analyze case studies. Open book tests will be held to promote self-learning. Practical related oral

	body and hormonal networks that regulate growth and repair.	Practical analysis of serum samples for understanding diagnosis of thyroid hormone pathophysiology and imbalances in calcium homeostasis.	questions will be asked.
IV	Appreciate the significance of the adrenal histology with respect to synthesis of cortical and medullary hormones. The concept of blood pressure regulation and electrolyte balance will be understood. Role of medullary hormone epinephrine in fight and flight response, general adaptation syndrome and the biochemical changes during acute and chronic stress will be learned.	Both black board mode and power point presentation mode will be used.	Regular class question-answer sessions. Students will be asked to prepare PowerPoint presentation on any topic of interest relating to hormone biochemistry. Internal assessment tests will be conducted.
V.	Gain knowledge about histology of gastrointestinal tract with respect to regulation secretion of gastrointestinal hormones, regulation of satiety and appetite. Other topics include glucose homeostasis and role of hormones and other factors in the same. Students will get an insight into dysregulations that lead to pathophysiologies like anorexia, bulimia, diabetes, obesity and metabolic syndrome.	Teaching will be conducted both through black board mode and power point presentation mode. Practical assessment of glucose homeostasis by RBG and GTT.	Internal assessment tests will be conducted Discussions using case studies will be conducted.
VI.	Understand the role of sex hormones, hormonal regulation of menstrual cycle, gestation, parturition and lactation and hormonal contraception.	Teaching will be conducted through black board and power point presentation. Useful video clips will be shown for better clarity.	Regular oral evaluation will be done. Internal assessment tests will be conducted

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Cellular communication, signal transduction, hypothalamic-hypophysial axis, hormones, calcium and glucose homeostasis, hormonal disorders.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPERS
<u>Human Physiology (BCH C-8)</u>
Semester – IV

1. Course Objectives

The objective of the course in human physiology is to provide a comprehensive study of the molecular and cellular mechanisms that govern the integrative working and regulation of the various organ systems in the human body. The course will provide a foundation of the physiological principles and the application of the same in real-life situations. It also outlines the factors and biochemical events that disrupt homeostasis leading to pathophysiology. The course will prepare students for higher education in any field related to molecular medicine.

2.1 Course Learning Outcomes

On successful completion of this core paper, students should be able to:

- Understand the basic organization and homeostatic control of the human body from the cell itself to organ systems and the functioning of the whole body.
- Comprehend and appreciate the importance of the fluid components of the body in regulating and connecting the various organ systems; particularly the heart and vascular system.
- Appreciate and understand the biochemical, molecular and cellular events that orchestrate the coordinate working of the organ systems that regulate life processes.
- Get a holistic understanding of the different organ systems with respect to their basic functioning, which involves both integrative learning and the regulatory roles of the Nervous and Endocrine system.
- Develop in students an inquisitive learning approach to seek answers regarding the complex workings of brain.
- Understand the factors that cause an imbalance to the Homeostatic control in the body and how these lead to disorders and diseases.
- Perform and analyze various physiological tests that examine the function of various systems of the human body.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to Human body and Understanding Homeostasis No. of hours: 3

Physiology: overview and definition, levels of structural organization, organ system. Body fluid compartments: intracellular, extracellular and interstitial fluid. Homeostasis: definition and control mechanisms (negative and positive feedback mechanisms).

UNIT II: Blood, Heart and Circulation: **No. of hours: 16**

Components of blood: Plasma - Composition, SPE - electrophoretic pattern of serum proteins, major plasma proteins and their role, Erythrocytes- erythropoiesis, function and metabolism, Leukocytes, Platelets- structure and function; Hemostasis and its molecular mechanism, role of platelets in coagulation, role of vitamin K in coagulation, Anticlotting and fibrinolytic systems. Anemias: definition and types (Hemolytic, hemorrhagic, megaloblast, pernicious, iron deficiency and aplastic anemia), polycythemia, Hemophilia and Thrombosis.

Anatomy of heart. Automacity of the cardiac muscle conducting fibres; Physiology of cardiac contracting muscle fibres, Relationship between cardiac cycle, heart sound, ventricular volumes and the ECG. Control of Heart rate and stroke volume. The vascular system: Arteries, arterial blood pressure and its measurement, Capillaries and bulk flow across the capillary walls, Veins and determination of venous pressure. Regulation of systemic arterial pressure. Long term and short-term regulation of cardiac efficiency and blood pressure. Hypertension, congestive heart disease, atherosclerosis, Heart failure and myocardial infarction.

UNIT III: Life Processes: **No. of hours: 22**

Respiratory physiology **-** Organization of the pulmonary system, site of gas exchange, Ventilation and lung mechanics. Inspiration, Expiration, Lung compliance and its determinants. Lung Volumes and Capacities. Transport of oxygen and carbon dioxide in blood. Haldane and Bohr's effect. Transport of hydrogen ions between tissues and lungs. Control of respiration. Hering-Breuer reflex. Asthma, Chronic Obstructive Pulmonary Disease (COPD), Hypoxia, Emphysema. *Renal physiology* **-** Anatomy of the kidney and the nephron. Regulation of renal blood flow. Cell biology of the Bowmans' capsule. Physiology of glomerular filtration and GFR. Tubular processing of the glomerular filtrate. Micturition. Regulation of ion and water balance. Urine concentration: The counter current multiplier system. Blood buffer systems, renal responses to acidosis and alkalosis. Assessment of kidney function. Glomerular nephritis. Dialysis: Hemodialysis and peritoneal dialysis. Diuretics. *Gastrointestinal and hepatic physiology* **-** Histology of the gastrointestinal tract. Propulsion and motility of food and digested material. Enteric reflexes. Secretory functions of the gastrointestinal tract, digestion and absorption of macronutrients and micronutrients. Peptic ulcer, Sprue, Celiac disease, IBD, regurgitation. Anatomy of the hepatic lobule and blood flow into the liver. Formation and secretion of bile. Enterohepatic cycle, detoxification in liver. Jaundice, liver cirrhosis and fatty liver.

UNIT IV: Muscle **No. of hours: 04**

Structure of Skeletal, smooth and cardiac muscle, Molecular mechanisms of skeletal muscle contraction: role of troponin, tropomyosin, and calcium in contraction, excitation-contraction coupling. Smooth muscle contraction and its control. Excitation-contraction coupling in cardiac muscle.

UNIT V: Reproductive Physiology: **No. of hours: 06**

Sex determination and differentiation. Development of female and male genital tracts. Oogenesis, Spermatogenesis, capacitation and transport of sperm, blood-testis barrier. Fertilization. Early development, Implantation. Placentation and Parturition.

UNIT VI: Neurophysiology: **No. of hours: 09**

Central Nervous system. Peripheral Nervous system. Blood brain barrier and CSF. Structure and maintenance of neurons. Functional classes of neurons. Membrane potentials: Resting Membrane Potential, Graded potentials, Action potential. Synapse: excitatory and inhibitory. Temporal and spatial summation. Neurotransmitters and neuromodulators (definition with examples). Somatic sensation: definition and cellular pathways of pain transmission and modulation. Physiology of EEG, sleep.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Hematology:

    a. Determination of Packed Cell Volume, Bleeding Time and Clotting time.
    b. Preparation of blood smear and estimation of differential leucocyte count.
    c. Enumeration of Blood cells: RBC and WBC counting, Calculation of blood Indices.
    d. Estimation of hemoglobin
2. Determination of total iron binding capacity.
3. Pulmonary function tests, spirometry and measurement of blood pressure.
4. Separation of isoenzymes of LDH by electrophoresis.
5. Case studies: Renal clearance, ECG, LFT, EEG (any two)

2.3 References

1. Fox, S.I. (2018) Human Physiology 15th ed., McGraw Hill International Publications, (New York) ISBN 978-1259864629.
2. Widmaier, E.P., Raff, H. and Strang, K.T. (2019) Vander's Human Physiology 15th ed., McGraw Hill International Publications (New York), ISBN: 978-1259903885

Additional Resources

1. Guyton, A.C. and Hall, J.E., (2016) Reed Textbook of Medical Physiology 13th ed., Elseviers India Pvt. Ltd. (New Delhi). ISBN: 978-1455770052
2. Sherwood, L. (2012) Introduction to Human Physiology 8th edition; Brooks/Cole, Cengage Learning. ISBN-13: 978-1133104544.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Understanding the concept of homeostasis and the mechanism for maintaining it; Learning the importance of different fluid components in	Teaching will be conducted both through black board mode and power point presentation mode; Using online data to discuss the	Internal assessment tests; Students will be given questions that are application based

	the human body; Comparing the different extracellular fluids with respect to composition and function.	importance of fluid compositions in diagnosis.	and require analytical skills
II.	Learning the importance of plasma compositional variations as an important diagnostic tool. Understanding the biochemistry and physiological role of RBC. Learning the biochemistry of blood coagulation and the factors that lead to bleeding and coagulation pathopysiologies. Understand the anatomy, physiology and biochemistry of cardiac function. Understand the biophysics of movement of blood through the vasculature. Discuss and appreciate the factors that lead to pathophysiology of the cardiovascular system.	Teaching will be conducted both through black board mode and power point presentation mode. Hematological practical's as an important diagnostic tool for anemias, infections and bleeding disorders.	Conduct of Internal assessment tests Case study with hematological reports.
III.	Learning the anatomy, physiology and biochemistry of pulmonary respiration and transport of oxygen for cellular utilization. Understand the importance of renal excretion of nitrogenous wasted by learning the process of urine formation. Understand the process of ingestion, digestion and assimilation of food. Learn to correlate biochemical mechanism to the manifestation of symptoms associated with the pathophysiologies related with the three important life processes- respiration, digestion and excretion.	Teaching will be conducted both through black board mode and power point presentation mode. Discussions with case studies and quizzes will be conducted to keep the students up-to-date with the information they have received and to gauge their conceptual understanding	Internal assessment tests will be conducted Analyzing case studies. Open book tests to promote self-learning.
IV	Understanding the biochemical mechanism that underlie the contraction of skeletal muscles. Comparing the differences in smooth, skeletal and cardiac muscle with respect to anatomy mechanism of contraction and regulation.	Teaching will be conducted both through black board mode and power point presentation mode.	Internal assessment tests will be conducted .

V.	Comparing the cell biology and physiology of spermatogenesis versus oogenesis. Understanding the mechanism that define, spermatogenesis, spermiogenesis, semen composition and capacitation. Learning the process of cellular development that support and regulate oogenesis. Understanding acrosomal reaction, cortical response and polyspermy that ensure proper fertilization. Understanding the physiological processes involved in implantation, placentation and parturition	Teaching will be conducted both through black board mode and power point presentation mode. Discussions using case studies will be conducted.	Internal assessment tests will be conducted. Analysis of case studies.
VI.	Understand the cellular composition and anatomy of the central and peripheral nervous system. Learning the process of synthesis, composition and function of CSF. Understand the mechanism of generation, propogation and regulation of action potentials. Learning about the neurophysiology and chemistry of sensory perception, learning and memory and sleep.	Teaching will be conducted both through black board mode and power point presentation mode.	Internal assessment tests will be conducted A PowerPoint presentation on any topic of interest relating to Neurophysiology and chemistry.

(**Assessment tasks enlisted here are indicative in nature)

4. Key words

Physiology, Homeostasis, life processes, heart, neurophysiology, reproduction

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Gene Organization, Replication and Repair (BCH C-9)
Semester - IV

1. Course Objectives

The objective of the course is to introduce to the students, the basic concepts of genome, DNA structure, genes, chromatin and chromosomes. It provides comprehensive understanding of DNA replication, recombination, mutations and repair processes in a way that students can apply this knowledge in understanding the life processes and develop an interest to pursue high quality research.

2.1 Course Learning Outcomes

- Students will acquire basic information about the structure of DNA and various forms of DNA, about organization of genome in various life forms, supercoiling of DNA and its significance
- Students will learn about the molecular basis of processes like DNA replication, recombination and transposition and understand the significance of these processes
- Students will learn about the various ways in which the DNA can be damaged leading to mutations and lesions and different ways to repair DNA damage

2.2 Course Contents

THEORY

CREDIT : 4 **TOTAL HOURS: 60**

UNIT I: Structure of DNA **No. of hours: 10**

Building blocks of DNA structure, Watson and Crick model, features of the double helix, various forms of DNA, denaturation and renaturation of DNA, hyperchromicity, melting temperature, factors affecting T_m of DNA molecules. Supercoiling of DNA, linking number, topoisomerases and their classification. Topoisomerase inhibitors and their clinical importance.

UNIT II: Genes and genomic organization **No. of hours: 10**

Definition of a gene, organization of genes in viruses, bacteria and eukaryotes, concept of split genes, introns, exons, satellite DNA, highly repetitive DNA, centromere and telomere sequences. Nucleosome structure and packaging of DNA into higher order structures.

UNIT III: Replication of DNA **No. of hours: 16**

General features of replication, the chemistry of DNA synthesis, DNA polymerase, the replication fork, enzymes and proteins in DNA replication, E coli DNA polymerases, stages of replication-initiation, elongation and termination, origin of replication, relationship between replication and cell division, replication in eukaryotes, end replication problem, telomerase, various modes of replication. Comparison of replication in prokaryotes and eukaryotes. Inhibitors of DNA replication and applications in medicine.

UNIT IV: Recombination and transposition of DNA **No. of hours: 12**

Homologous recombination, biological role and models for homologous recombination, proteins and enzymes in homologous recombination, site-specific recombination, serine and tyrosine recombinases. Transposition, the three classes of transposable elements-DNA transposons, virus-like retrotransposons and poly-A retrotransposons. DNA transposition by cut and paste and replicative mechanism.

UNIT V: Molecular basis of mutations **No. of hours : 6**

Importance of mutations in evolution of species. Types of mutations - transition, transversion, frame shift mutations. DNA damage by hydrolysis, alkylation, oxidation and radiation. Mutations caused by base analogs and intercalating agents. Ames test.

UNIT VI: Various modes of DNA repair **No. of hours : 6**

Replication errors and their repair, mismatch repair system. Repair of DNA damage-direct reversal of DNA damage, base excision repair, nucleotide excision repair, recombination repair, trans-lesion DNA synthesis. DNA repair and diseases.

PRACTICALS

CREDITS : 2 **TOTAL HOURS : 60**

1. To hydrolyze DNA and separate nucleotide bases by paper chromatography
2. To plot ultraviolet absorption spectrum of DNA
3. Determination of DNA concentration by A_{260nm}
4. DNA estimation by Diphenylamine (DPA) method
5. Determination of the melting temperature of DNA
6. Isolation of chromosomal DNA from *E coli* cells

2.3 References

1. Nelson, D.L. and Cox, M.M (2017) *Lehninger: Principles of Biochemistry* (7th ed.) W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.
2. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008) *Watson: Molecular Biology of the Gene* (7th ed.), Cold Spring Harbor Laboratory Press, Cold spring Harbor (New York), ISBN:0-321-50781 / ISBN-13: 9780321762436

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn about the complexity of DNA double helix structure, nature of nuclotides, melting of DNA and understand the importance of supercoiling of DNA.	Teaching using chalk and board; Power point presentations; Oral discussion sessions in the class Practical learning of hydrolysis of DNA, separation of nucleotide bases using paper chromatography, melting temperature of DNA.	Oral questions will be asked in the class. Problems will be assigned to test student's analytical ability. Asking practical related questions.
II.	Gain insight into the organization of DNA and how a long DNA molecule gets packaged in a small cell.	Power point presentations will be used to teach levels of DNA packaging ; Oral discussion sessions in the class	Regular question-answer sessions in the class. Class tests will be conducted for internal assessment
III.	Understand the details of DNA replication and importance of various proteins and enzymes involved in replication and application of inhibitors	Teaching will be carried out by displaying colourful models for steps of replication using slides and the rest using chalk and board method; Discussion sessions in the class	Students will be challenged with analytical problems, puzzles and assignments related to replication of DNA.
IV	Learn to appreciate the mechanism and importance of homologous and site specific recombination and transposition.	Power point presentations will be used to explain recombination process; Interactive discussion sessions in the class	Regular question-answer and quiz sessions in the class, demonstration by students with the help of models to test and improve their understanding.
V	Know about DNA mutations and understand how DNA can be damaged by chemical mutagens and radiation.	Teaching using chalk and board; Power point presentations; Oral discussion sessions in the class	Regular class interaction and analytical problem solving in the class. Class tests will be conducted for internal assessment
VI.	Will be familiarized with various strategies of DNA repair and diseases associated with DNA repair problems.	Power point presentations as well as chalk and board method will be used for teaching, Oral discussion about repair and its problems along with movie display.	Various analytical problems will be assigned to students related to DNA repair and related disorders.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

DNA, Double helix, Supercoiling, Recombination, Transposition, DNA Repair

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Metabolism of Amino Acids and Nucleotides (BCH C-10)
Semester - IV

1. Course Objective

The main objective of the course is to offer detailed and comprehensive knowledge about the synthesis and degradation pathways of amino acids and nucleotides and their importance in the proper functioning of the cells. This course also interrelates the metabolism of these molecules with respect to health diseases in addition to providing overview of inhibitors of metabolism for treating the diseases of metabolic disorders.

2.1 Course Learning Outcomes

At the end of the course the students will be able to:

- Extend their school level concepts of nitrogen cycle to understand the mechanism by which nitrogen is fixed by microbes and how it's incorporation in diet is critical to human nutrition as well as comprehend the mechanism by which ammonia is incorporated in biomolecules
- Systematically learn the breakdown and synthesis of amino acids and nucleotides in humans and recognize its relevance with respect to nutrition and human diseases
- Gain knowledge of how amino acids are converted into a variety of precursors
- Acknowledge the role of inhibitors of nucleotide metabolism which are potentially being used as chemotherapeutic drugs
- Comprehend how the amino acid and nucleotide metabolism are integrated with carbohydrate and lipid metabolism

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Overview of Nitrogen and Amino Acid Metabolism **No. of hours: 8**

Nitrogen cycle, incorporation of ammonia into biomolecules. Digestion and absorption of dietary proteins. Role of essential and non-essential amino acids in growth and development. Protein calorie malnutrition - Kwashiorkar and Marasmus, Nitrogen balance. Metabolic fates of amino groups. Transamination, role of pyridoxal phosphate, glucose-alanine cycle, Kreb's bicycle, urea cycle, its regulation and inherited defects of urea cycle. Gamaglutamyl cycle.

UNIT II: Catabolism and Biosynthesis of Amino Acids **No. of hours: 18**

Catabolic pathways of individual amino acids. Glucogenic and ketogenic amino acids. Metabolism of one carbon units. Disorders of amino acids metabolism, phenylketonuria, alkaptonuria, maple syrup urine disease, methyl malonic acidemia (MMA), homocystinuria and Hartnup's disease. Overview of amino acid synthesis. Biosynthesis of non-essential amino acids and its regulation.

UNIT III: Precursor Functions of Amino Acids **No. of hours: 8**

Biosynthesis of creatine and creatinine, polyamines (putresine, spermine, spermidine), catecholamines (dopamine, epinephrine, norepinephrine) and neurotransmitters (serotonin, GABA). Porphyrin biosynthesis, catabolism and disorders of porphyrin metabolism.

UNIT IV: Biosynthesis, Degradation of Purine and Pyrimidine Nucleotides
No. of hours: 14

De novo synthesis of purine and pyrimidine nucleotides, regulation and salvage pathways. Digestion of nucleic acids, degradation of purine and pyrimidine nucleotides. Inhibitors of nucleotide metabolism. Disorders of purine and pyrimidine metabolism – Lesch-Nyhan syndrome, Gout, SCID, adenosine deaminase deficiency.

UNIT V: Deoxyribonucleotides and Synthesis of Nucleotide Triphosphate and Co-enzymes
No. of hours: 6

Biosynthesis of deoxyribonucleotides and its regulation, conversion to triphosphates, biosynthesis of coenzyme nucleotides.

UNIT VI: Integration of Metabolism **No. of hours: 6**

Integration of metabolic pathways (carbohydrate, lipid and amino acid metabolic pathways), tissue specific metabolism (brain, muscle, and liver).
Practical

PRACTICALS

CREDITS : 2 **TOTAL HOURS : 60**

1. Assay of serum transaminases – SGOT and SGPT.
2. Estimation of serum urea.
3. Estimation of serum uric acid.
4. Estimation of serum creatinine.
5. Estimation of bilirubin
6. Assay of glutamate dehydrogenase

2.3 References

1. Berg, J.M., Tymoczko, J.L. and Stryer L., (2012) *W.H. Biochemistry* (7th ed.), Freeman and Company (New York), ISBN:10: 1-4292-2936-5, ISBN:13:978-1-4292-2936-4.
2. Devlin, T.M. (2011) *Textbook of Biochemistry with Clinical Correlations* (7th ed.), John Wiley & Sons, Inc. (New York), ISBN:978-0-470-28173-4 / BRV ISBN:978-0-470-60152-5.
3. Nelson, D.L. and Cox, M.M (2017) *Lehninger: Principles of Biochemistry* (7th ed.) W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn about the concepts of nitrogen cycle, nitrogen fixation and assimilation, importance of nitrogen in human nutrition and its deficiency-associated disorders. Besides, students will be introduced to metabolic fates of amino groups, various metabolic cycles, their regulation and inherited defects of urea cycle.	Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted through both black board mode and powerpoint presentation mode.	Internal assessment tests (midterm and end-term) will be conducted.
II.	Students will gain insight into the breakdown and synthesis of amino acids. Further, the students will gain knowledge about various disorders related to amino acids.	Chalk and board teaching method will be largely employed. Oral presentations by the students will help them learn the subject better.	Students will be given assignment on different topics specially disorders and will be asked to deliver a power-point presentation on the assigned topics.
III.	Students will learn how amino acids are converted into a variety of precursors, such as creatine and creatinine, polyamines catecholamines, neurotransmitters and porphyrin biosynthesis, catabolism and disorders of porphyrin metabolism.	Class discussions will be conducted in various group of students. Lecture by teachers.	MCQ based Internal assessment test will be conducted. Mid term examination evaluation.
IV	Students will gain insight into *de novo* synthesis and degradation of purine and pyrimidine nucleotides, regulation and salvage pathways. Further, the students will learn about the inhibitors of nucleotide metabolism and disorders related to purine and pyrimidine metabolism.	Oral questions will be asked by the teachers that will be orally answered by the students. Chalk and board teaching along with powerpoint presentations.	Internal assessment test (end term) will be conducted. Several short quiz will be held to motivate students
V.	Students will gain knowledge about biosynthesis of deoxyribonucleotides, its	Students will be asked to orally revise the	Students will be given

	regulation and conversion to triphosphates, Further they will also learn about the biosynthesis of coenzyme nucleotides.	previous class before every new class. Student presentations and class discussions.	assignment on various topics and will be asked to deliver a power-point presentation on the assigned topics. End term examination evaluation will be conducted.
VI.	Students will learn about the integration of various metabolic pathways and their cross-talk in specific tissues like brain, muscle, and liver.	Chalk and board teaching method will be largely employed. Oral presentations by the students will help them learn the subject better.	Students will be given assignment on different topics specially disorders and will be asked to deliver a power-point presentation on the assigned topics.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Nitrogen Balance, Protein calorie malnutrition, Transamination, Amino acid metabolism, Purine and Pyrimidine Metabolism, Porphyrin metabolism, Urea cycle, Metabolic disorders, Integration of metabolism

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Concepts in Genetics (BCH C-11)
Semester – V

1. Course Objectives

The aim of the course is to provide students with an understanding of both classical and modern concepts in genetics with special emphasis on the areas of transmission genetics, molecular and developmental genetics, mapping techniques, chromosomal aberrations and population genetics. Students will gain a hands-on training experience of culturing and conducting experiments on the genetic model system *Drosophila melanogaster*. The course also works as preparation for further studies in a Master's programme in molecular biology or related topics.

2.1 Course Learning Outcomes

On successful completion of the course, the students will be:

- Understanding the principles of Mendelian genetics, extensions and applications
- Learning and appreciating the various factors that confer genotypic and phenotypic variability.
- Using the concepts of bacterial and viral genetics to understand resistance patterns and to create linkage and genetic maps.
- Able to use statistical tools to analyze biological data.
- Able to apply the principles of transmission and inheritance in real life situations.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Principles of heredity and transmission genetics: **No of hours: 16**

Mendelian genetics and chromosomal basis of heredity: Mendelian laws and ratios; Concept of segregation and independent assortment, and its chromosomal basis. Laws of probability & binomial expansion, formulating and testing genetic hypothesis, chromosomal basis of Mendelism - Sutton and Boveri hypothesis with other supporting experimental evidences; *Extensions to Mendelian genetics:* Complementation test using examples from Drosophila eye colour mutants to differentiate allelic variants from gene interaction. Allelic variation and gene function - dominance relationships, multiple alleles, lethal alleles and null alleles. Pleiotropic gene interaction - epistatic and non- epistatic, interaction between gene(s) and environment. Penetrance and expressivity, norm of reaction and phenocopy; *Human pedigree analysis:* Pedigree conventions, characteristics of dominant and recessive inheritance; sex linked, sex influenced and sex limited traits. Applications of pedigree analysis.

UNIT II: Genetics of bacteria and viruses **No. of hours: 7**

Concept of cistron. Bacterial and viral genomes, Mechanism of genetic exchange - conjugation, transformation and transduction. Gene mapping in bacteria.

UNIT III: Linkage, crossing over and mapping techniques: **No. of hours: 10**

Linkage and crossing over, genetic mapping in eukaryotes, centromere mapping with ordered tetrads, cytogenetic mapping with deletions and duplications in *Drosophila*, detection of linked loci by pedigree analysis in humans, LOD score, somatic cell hybridization for positioning genes on chromosomes and physical maps using molecular markers.

UNIT IV: Molecular genetics **No. of hours: 12**

Sex determination and genetic control of development: Genetic basis of sex determination in Humans, *Drosophila melanogaster* and *C. elegans. Drosophila* development-maternal effect genes, morphogens and zygotic genes; Genetic basis of flower development in *Arabidopsis*-ABC model; *Non-nuclear inheritance and Epigenetics:* Extra nuclear inheritance, tests for organelle heredity and maternal effect; Mechanism of dosage compensation; X chromosomal inactivation in humans and *Drosophila melanogaster*. Epigenetic mechanisms of transcriptional regulation. Monoallelic expressions and Genomic imprinting.

UNIT V: Chromosomal aberrations **No. of hours: 7**

Variations in chromosome number: aneuploidy and polyploidy. Variations in chromosome structure- inversions, deletions, duplications and translocations.

UNIT VI: Quantitative, Population and Evolutionary Genetics **No. of hours: 8**

Inheritance of complex trait, analysis of quantitative traits, narrow and broad sense heritability, quantitative trait loci (QTL) and their identification. Hybrid vigor. Hardy-Weinberg law, predicting allele and genotype frequencies and exceptions to Hardy-Weinberg principle. Molecular evolution - analysis of nucleotide and amino acid sequences, molecular phylogenies, homologous sequences, phenotypic evolution and speciation.

PRACTICALS

CREDITS : 2 **TOTAL HOURS : 60**

1. Squash preparation of salivary glands of Dipteran larva to observe polytene chromosomes.
2. Induction of polyploidy in onion roots.
3. Smear technique to demonstrate sex chromatin in buccal epithelial cells.
4. Monohybrid crosses in *Drosophila* for studying autosomal and sex linked inheritance.
5. PTC testing in a population and calculation of allelic and genotype frequencies.
6. Study of abnormal human karyotype and pedigrees (dry lab)

2.3 References

1. Griffiths, A.J.F, Wessler, S. R, Carroll, S. B. and Doebley, J. (2017) *An Introduction to Genetic Analysis*, (11th ed.), W.H. Freeman & Company (New York), ISBN: 1464109486
2. Pierce, B.A. (2012) *Genetics - A Conceptual Approach*, (6h ed.), W.H. Freeman & Co. (New York), ISBN:13:978-1-4292-7606-1 / ISBN:10:1-4292-7606-1.
3. Snustad, D.P. and Simmons, M.J. (2012) *Genetics* (6th ed.), John Wiley & Sons. (Singapore), ISBN: 978-1-118-09242-2.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Understanding Mendel's laws and ratios; Understand relationship between genetic inheritance, generation of variation and cell division; Relating genes to chromosomes- chromosomal basis of heredity; Use of statistical tools in testing genetic hypothesis; Complementation test relating extensions to Mendelian ratios due to allelic variations; Understand gene interactions- both epistatic and non-epistatic; Concept of Penetrance, expressivity, phenocopy and pleiotropy; Understanding how to draw a human pedigree chart and analyze it for determining inheritance patterns	Students will be practically shown examples from crosses of different *Drosophila* eye colour mutant strains for explaining complementation test. Formulation and testing of genetic hypothesis will be explained using experiments with *Drosophila* crosses as well as exemplary numerical problems. Students will be encouraged to apply pedigree analysis in real life situations by helping them make their own family pedigrees for certain overt heritable physical features and genetic condition or disease, if any.	Students will be given questions that are application based and require use of statistical tools like probability and chi-square analysis and hypothesis testing for goodness of fit.
II.	Understand the concept of cistron, operon and gene; Basics of bacterial and viral genomes; Mechanisms of genetic exchange in prokaryotes like conjugation, transformation and transduction; Gene mapping in bacteria.	Teaching will be conducted both through black board mode and power point presentation mode. Discussions and quizzes will be conducted to keep the students up-to-date with the information they have received and to gauge their conceptual understanding	Powerpoint presentation on the assigned topics. Students will be given questions that are application based and require analytical skills
III.	Understand the of concept of recombination and linked genes; Use recombination	Teaching will be conducted both through black board	Internal assessment tests will be conducted

	frequencies to determine gene order and distance; Genetic mapping in eukaryotes using test crosses; Gene to centromere mapping with ordered tetrads and cytogenetic mapping; Detection of linked loci by pedigree analysis in humans and the concept of LOD score; Somatic cell hybridization for locating gene on a chromosome; Physical mapping using molecular markers.	mode and power point presentation mode. Numerical problems for genetic mapping using three point cross would be given for practice in class.	Questions on drawing a genetic map with gene order, map distance. and centromere mapping
IV	Understand the difference in the genetic basis of sex determination in Humans, *Drosophila* and *C.elegans;* Understand the role of maternal effect genes on axis formation during development using *Drosophila* as a model of study Role of zygotic and homeotic genes in development using *Drosophila* as a model of study; Genetic control of flower development in *Arabidopsis;* Nonnuclear inheritance and its role in determination of phenotypes; Epigenetic phenomenon like dosage compensation and Genomic Imprinting.	Teaching will be conducted both through black board mode and power point presentation mode. Discussions and quizzes will be conducted to keep the students up-to-date with the information they have received and to gauge their conceptual understanding	A PowerPoint presentation on any topic of interest relating to the concept of Epigenetics, non-nuclear inheritance and sex determination.
V.	Students will learn about various structural and numeric chromosomal aberrations possible in both plants and animals; Understand the disadvantages as well as some advantages of such aberrations.	Teaching will be conducted both through black board mode and power point presentation mode. Discussions using case studies will be conducted to help students understand the karyotype analysis.	Internal assessment tests will be conducted Analysis of case studies in groups.
VI.	Understand the concept of polygenic inheritance, additive gene effect, OTL, heterosis and hybrid vigor; Understand concept of gene pool, allelic and genotypic frequencies; Understand Hardy Weinberg principle and its limitations; Understand concept genetic	Teaching will be conducted both through black board mode and power point presentation mode. Discussions using population genetics based case studies will be conducted. Practical collection of data from	Numerical analysis and case study analysis.

	drift, founder effect, genetic bottleneck; Factors that influence gene flow, fitness of a population and speciation.	population to test Hardy-Weinberg principle.	

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Mendelian genetics, Allelic and gene interaction, Gene mapping, Microbial genetics, Pedigree analysis, Epigenetics, Quantitative, Development, Population and Evolutionary Genetics

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
<u>Gene Expression and Regulation (BCH C-12)</u>
Semester - V

1. Course Objective

The objective of the course is to introduce to the students the basic knowledge about how genes are transcribed and how translation takes place in prokaryotes and eukaryotes and how these processes are regulated, so that students can apply this knowledge in enhancing their analytical and problem solving skills.

2.1 Course Learning Outcomes

After completion of the course students will:

- acquire basic knowledge about the processes of transcription and translation in prokaryotes and eukaryotes
- learn about the features of the genetic code and various experimental approaches used to crack the code
- develop understanding of the molecular basis of RNA processing and RNA splicing
- learn about the various ways in which these biological processes are regulated and the significance of regulation in maintaining life forms

2.2 Course Contents

THEORY

CREDIT : 4 **TOTAL HOURS : 60**

UNIT I: Transcription in prokaryotes **No. of hours : 8**

Comparison between transcription and DNA replication, RNA polymerases, transcription cycle in bacteria, sigma factor, bacterial promoters, identification of DNA binding sites by DNA footprinting, various stages of RNA synthesis, initiation, elongation and termination, rho-dependent and rho-independent termination. Inhibitors of transcription and applications as antimicrobial drugs.

UNIT II: Transcription in eukaryotes **No. of hours : 8**

Comparison between initiation, elongation and termination of prokaryotic and eukaryotic transcription. Introduction on basal transcription machinery and three classes of eukaryotic RNA polymerases – I, II and III and their respective promoters. Details on transcription by RNA polymerase II, features of RNA polymerase II core promoters and general transcription factors. Identification of DNA binding sites by DNA foot printing. Inhibitors of eukaryotic transcription and their applications.

UNIT III: RNA Processing **No. of hours : 8**

Various types of RNA processing- polyadenylation and capping, processing of rRNA and tRNA. Chemistry of RNA splicing, the spliceosome machinery, splicing pathways, group I and group II introns, alternative splicing, exon shuffling and RNA editing.

UNIT IV: Translation of proteins **No. of hours : 16**

Salient features of the genetic code, triplet nature, degenerate, wobble in the anticodon. Experimental approaches used to decipher the genetic code. Suppressor tRNAs. Exceptions to the nearly universal genetic code. Messenger RNA, transfer RNA, charging of tRNA. The structure of ribosome. Three stages of translation-initiation, elongation and termination. Translation in eukaryotes. Regulation of translation. Comparison of prokaryotic and eukaryotic protein synthesis. Inhibitors of translation and their clinical importance.

UNIT V: Regulation of gene expression in prokaryotes **No. of hours : 10**

Strategies for gene regulation, negative and positive regulation, concept of operons, regulatory proteins, activators, repressors, DNA binding domains, regulation of lac operon and the concept of combinatorial control, trp operon. Regulatory RNAs in bacteria, small RNA and riboswitches.

UNIT VI: Regulation of gene expression in eukaryotes **No. of hours : 10**

Gene regulation by chromatin remodeling, regulation of galactose metabolism in yeast, action Gof enhancers and insulators, working of activators and repressors, concept of combinatorial control. Regulatory RNAs in eukaryotes: synthesis and mechanism of siRNA and miRNA. Comparison of regulatory mechanisms of gene expression in prokaryotes and eukaryotes.

PRACTICALS

CREDITS : 2 **TOTAL HOURS: 60**

1. Estimation of RNA by Orcinol Method
2. Extraction of total nucleic acids from plant tissue
3. To study growth curve and diauxic growth curve effect in *E. coli*
4. Isolation of total RNA from bacteria/yeast
5. To study the effect of inhibitors on protein synthesis

2.3 References

1. Nelson, D.L. and Cox, M.M (2017) *Lehninger: Principles of Biochemistry* (7th ed.) W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.
2. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008) *Watson: Molecular Biology of the Gene* (7th ed.), Cold Spring Harbor Laboratory Press, Cold spring Harbor (New York), ISBN:0-321-50781 / ISBN-13: 9780321762436

Additional Resources:

1. Lewin, B., Krebs, J.E., Kilpatrick, S.T., Goldstein, E.S., (2018) *Lewin's Gene X* (10th edition). Bartlett Learning publishers, LLC, ISBN: 978-0-7637-6632-0.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	The student will learn about the difference between DNA replication and transcription, RNA polymerases and details of bacterial transcription	Traditional chalk and board method of teaching and regular class room discussion. Videos to showcase the structure and assembly of the transcription initiation complex and the stages of transcription in real time.	Problem solving assignments, regular question answer sessions, MCQs and unit-test for internal assessment
II.	Will appreciate the basics of prokaryotic and eukaryotic transcription, key features of the three classes of eukaryotic RNA polymerases, different promoters and use of various inhibitors.	Audio visual presentation with appropriate examples and black board teaching, regular class room discussion Estimation of RNA and isolation of RNA will be shown through practicals.	Regular question-answer sessions in the class, learning exercises through quiz and puzzles, analytical question solving to improve student understanding. Monitoring of practical record keeping, oral questions related to practicals
III.	Introduced to the ways of RNA processing, chemistry of splicing, various types of splicing and RNA editing	Chalk and board method of teaching; Power point presentation showing the steps of splicing and RNA editing and various examples of splicing.	Oral questions will be asked in the class. Problems will be assigned to test student's analytical ability.
IV	Able to describe the salient features of genetic code, triplet nature, wobble in the anticodon. Stages of translation and inhibitors of translation	Classroom teaching of discoveries from research papers, chalk and board method of teaching and use of powerpoint presentation. Practical demonstration of translation inhibitor. Audio visual to demonstrate the experimental strategies used to decipher the genetic code	Students will be challenged with analytical problems, puzzles and assignments related to genetic code and other topics covered in the class.
V.	Gain knowledge about regulation of gene expression in prokaryotes, concept of operon, regulatory RNA and riboswitches.	Traditional chalk and board method of teaching, audio visual presentation and regular class room discussion. Supportive powerpoint slides to display the structure of riboswitches	Various analytical problems will be assigned to students related to prokaryotic gene expression, oral question answer sessions will be held in the class.

VI.	Learn about regulation of gene expression in eukaryotes, working of activators and repressors and small RNA mediated silencing mechanisms.	Classroom teaching using powerpoint presentations along with use of traditional chalk and board class room discussion. audio visual aids to present RNA silencing mechanisms	Regular classroom interaction and analytical problem solving related to gene expression and silencing. Class tests will be conducted for internal assessment

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

RNA, Transcription, Translation, Genetic code, Gene expression, Operon

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Genetic Engineering and Biotechnology (BCH C-13)
Semester – VI

1. Course objectives:

The objective of the course is to teach the basics of theoretical and practical aspects of recombinant DNA technology and various techniques for DNA manipulation in prokaryotes and eukaryotes. Applications of these techniques in production of recombinant therapeutic proteins and vaccines will also be outlined in this course.

2.1 Course Learning Outcome

The students will be able to understand:

- The process for isolation and engineering of DNA using restriction and modification enzymes.
- Use of cloning and expression vectors.
- The methods for creation of genomic and cDNA libraries, their applications and use.
- Understanding the methods for protein production and their application in industrial production systems.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: The basic principle of gene cloning **No of hours: 10**

Restriction and modification systems, restriction endonucleases and other enzymes used in manipulating DNA molecules. Ligation of DNA molecules. DNA ligase, sticky ends, blunt ends, linkers and adapters, homopolymer tailing, Synthetic oligonucleotides.

UNIT II: Cloning vectors for prokaryotes and eukaryotes **No of hours: 12**

Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors based on *E. coli* plasmids, pBR322, pUC8, pGEM3Z. Cloning vectors based on M13 and λ bacteriophage, and in vitro packaging. Vectors for yeast, Ti-plasmid, and retroviral vectors, high capacity vectors BAC and YAC.

UNIT III: Introduction of DNA in cells, selection for recombinants and clone identification

No of hours: 10

Uptake of DNA by cells. Selection and identification for transformed cells, insertional inactivation, blue-white selection. Transfection. Chemical and physical methods of DNA introduction into cells. The problem of selection, direct selection, marker rescue. Identification of recombinant phages, cDNA and Genomic libraries, identification of a clone from gene library, colony and plaque hybridization probing, Southern and Northern hybridization, methods based on detection of the translation product of the cloned gene.

UNIT IV: Expression of cloned genes **No of hours: 06**

Vectors for expression of foreign genes in *E. coli*, cassettes and gene fusions. Hybrid promoters: trc, tac, λpL and T7 promoter based expression vectors. Challenges in producing recombinant protein in *E. coli*. Production of recombinant protein by eukaryotic cells. Fusion tags such as, poly-histidine, glutathione, maltose binding protein and their role in purification of recombinant proteins.

UNIT V: Polymerase chain reaction and DNA sequencing **No of hours: 10**

Fundamentals of polymerase chain reaction, Types of PCR; hot start, multiplex, reverse transcriptase PCR and Nested PCR, quantitative PCR, Primer, designing for PCR. Cloning PCR products. DNA sequencing by Sanger's method including Automated Sanger's DNA sequencing. Introduction to Next Generation Sequencing.

UNIT VI: Applications of genetic engineering in Biotechnology **No of hours: 12**

Site–directed mutagenesis, Protein engineering (T4-lysozyme), yeast two hybrid systems, Production of recombinant pharmaceuticals such as insulin, human growth hormone, factor VIII. Recombinant vaccines. Gene therapy (SCID), Applications in agriculture – *Bt* cotton, glyphosate herbicide resistant crops, ethical concerns.

PRACTICALS

CREDITS : 2 **TOTAL HOURS: 60**

1. Transformation of *E. coli* cells with plasmid DNA.
2. Isolation of plasmid DNA from *E. coli* cells.
3. Digestion of plasmid DNA with restriction enzymes.
4. Amplification of a DNA fragment by PCR.
5. Complementation of β−galactosidase for Blue and White selection.

2.3 References

1. Brown, T.A. (2010) *Gene Cloning and DNA Analysis* (6th ed.), Wiley-Blackwell publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
2. Glick B.R., Pasternak, J.J. and Patten, C.L., (2010) *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4th ed.), ASM Press (Washington DC), ISBN: 978-1-55581-498-4 (HC).
3. Michael R Green and J. Sambrook (2014) *Molecular Cloning: A laboratory manual*, (4th ed.), Cold spring Harbor laboratory press (3vol.), ISBN: 978-1-936113-42-2
4. Primrose, S.B., and Twyman, (2006) *Principles of Gene Manipulation and Genomics* (7th ed.), R. M., Blackwell publishing (Oxford, UK) ISBN:13: 978-1-4051-3544-3.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn about the significance of Restriction and Modification System, properties and uses of different restriction and modification enzymes and DNA as well as Methods to ligate DNA molecules	Describe different systems, and their applications with case studies using Chalk and board along with power point presentations.	The students will be given home assignment at the end of first unit.
II.	Students will learn about the biology of different types of vectors systems including plasmids and bacteriophages used in prokaryotes and eukaryotes along with their applications.	Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any.	The students will undergo internal test with syllabus covered in the two units and their answers will be discussed in the following class.
III.	Students will know about DNA transfer to cells, distinguishing between recombinants and non-recombinants and to identify a specific clone among many clones in a library	Chalk and board along with power point presentations, regular question answer activities. Consultation of text books.	The students will be given home assignment at the end of third unit.
IV	Students will earn about the signals that promote expression of heterologous proteins from expression vectors and their purification from the medium	Concepts will be taught using chalk and board and notes; Power point presentations for images for clarity of concepts;	The students will undergo internal test with syllabus covered in the third and the fourth units and their answers will be discussed in the following class.

V.	Students shall become aware of the basic process of PCR, different types of PCR and DNA sequencing techniques	Teaching using chalk and board; Oral discussion sessions in the class.	The students will be given home assignment at the end of fifth unit.
VI.	The students shall be able to understand how theoretical knowledge of RDT translates into production of commercially useful proteins that are used in medicine and about creating GMOs, while maintaining strong ethics	Teaching and learning activity will mainly include extensive discussions; chalk and board teaching; Discussion about principle and logic behind each methods and experiment.	The students will undergo internal test with syllabus covered in the fifth and the sixth units and their answers will be discussed in the following class.

(**Assessment tasks enlisted here are indicative in nature)

4. Key Words:

Genetic Engineering, Recombinant Proteins expression and purification, Biotechnology, cloning

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Immunology (BCH C-14)
Semester VI

1. Course Objective

This course describes the molecular and cellular basis of the development and function of the immune system. The course will provide the basic framework in immunology that will cover the major topics including innate and adaptive immunity, antibodies and antigens, the molecular events leading to the generation of antibody, humoral and cell mediated adaptive immune response, hypersensitivity, self-tolerance, autoimmunity and vaccines.

2.1 Course Learning Outcomes

Upon completion of this course, a student will be able to:

- Trace the history and developments in immunology.
- Have an overview of the immune system including cells, organs and receptors.
- Describe the basic mechanism, differences and functional interplay of innate and adaptive immunity
- Understand Antigens & its Recognition, antigen processing and presentation
- Understand the structure & functions of different classes of Immunoglobulins, and understand the genetic basis of antibody diversity
- Define the cellular and molecular pathways of humoral and cell-mediated immune responses
- Describe the mechanisms involved in different types of hypersensitivity
- Explain the principles of tolerance and autoimmunity
- Understand Immunotherapies and basic concept of Vaccines
- Summarize role of immunity in protection against pathogens

2.2 Course contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Immune System and Innate Immunity **No. of hours: 10**

Historical Perspective, Innate and Adaptive Immunity, Hematopoiesis, cells of the immune system, primary and secondary lymphoid organs and tissues. Anatomical barriers, cell types of innate immunity, soluble molecules and membrane associated receptors (PRR), connections between innate and adaptive immunity, localized and systemic response. Complement activation by classical, alternate and MB lectin pathway, biological consequences of complement activation, regulation and complement deficiencies

UNIT II: Antigens and Antibody **No. of hours: 12**

Antigens, carriers, adjuvants and haptens, factors responsible for immunogenicity, B and T cell epitopes. Structure, classes and subclasses of immunoglobulins (Ig, Ig fold), effector functions of antibody, antigenic determinants on Ig, Ig super family. Monoclonal antibodies production and applications

UNIT III: Biology of the B Lymphocyte & Humoral Immunity **No. of hours: 10**

Dreyer-Bennett hypothesis, multigene organization of Ig locus, mechanism of V region DNA rearrangement, mechanisms of antibody diversity. Antigen independent phase of B cell maturation and selection, humoral response – T-dependent and T-independent response, anatomical distribution of B cell populations

UNIT IV: Biology of the T Lymphocyte & Cell Mediated Immunity **No. of hours: 12**

General organization and inheritance of MHC, structure, distribution and role of MHC class I and class II proteins, pathways of antigen processing and presentation. Structure and role of T cell receptor (TCR) and co-receptor, T cell development, generation of receptor diversity, selection and differentiation. General properties of effector T cells, cytotoxic T cells (Tc), natural killer cells; NK - T cells and antibody dependent cellular cytotoxicity (ADCC).

UNIT V: Autoimmunity and Hypersensitivity **No. of hours: 10**

Self-tolerance and possible mechanisms of induction of autoimmunity, Organ specific and systemic autoimmune diseases, Gell and Coombs classification, IgE mediated (Type I) hypersensitivity, antibody mediated cytotoxic (Type II) hypersensitivity, immune complex mediated (type III) hypersensitivity and delayed type (Type IV) hypersensitivity

UNIT VI: Transplantation Immunology and Vaccines **No. of hours: 6**

Immunological basis of graft rejection, clinical manifestations, immunosuppressive therapy and privileged sites. Vaccines - active and passive immunization, types of vaccines

PRACTICALS

CREDITS : 2 **TOTAL HOURS: 60**

1. Isolation of lymphocytes from blood / spleen.
2. Purification of immunoglobulins from serum
3. Assays based on precipitation reactions - Ouchterlony double immunodiffusion (DID) and Mancini radial immunodiffusion (SRID).
4. Assays based on agglutination reactions - Blood typing (active) & passive agglutination.
5. Enzyme linked immunosorbent assay (ELISA) & DOT ELISA

2.3 References

1. Coico, R and Sunshine, G. (2009) *Immunology: A Short Course* (6th ed.), John Wiley& sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.
2. Kindt, T.L., Goldsby, R.A. and Osborne, B.A. (2007) *Kuby Immunology* (6th ed.), W.H Freeman and Company (New York), ISBN:13: 978-0-7167-8590-3 / ISBN: 10:0-7617-8590- 0.
3. Murphy, K., Mowat, A., and Weaver, C.T. (2012) *Janeway's Immunobiology* (8th ed.), Garland Science (London & New York), ISBN: 978-0-8153-4243-4

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be taught about the historical perspective of immunology, They will learn about the cells and organs of the immune system and innate immune mechanisms..	Chalk and board method will be used and powerpoint presentation for depicting the structure of cells and hematopoiesis	Students will be asked to correlate the importance of immunity and health by asking them to site examples from their experience
II.	Students will be explained the concept of foreign molecules acting as antigens. What are antibodies and their basic structure will be dealt with. Will focus on how antigen and antibody can interact with each other	Chalk and board method will be used and powerpoint presentation for depicting the structure of antibodies	MCQ based assignments will be given to students to check their understanding of the subject. Students will be asked to come up with examples where antigen – antibody interactions can be utilized for diagnostic purposes. This will help them to understand the importance of these components of the immune system.
III.	Students will understand how antibodies are generated in the body. They will understand the importance of humoral response in infections	Chalk and board method will be used and powerpoint presentation for understanding antibody diversity and production	Discussion related to transcription and translation of proteins will be held and comparisons with antibody production will be highlighted. Class tests will be taken.

IV	Students will be exposed to the cellular arm of immunity. The various cells which participate in cellular response will be dealt with. Cytotoxic action of T cells will be discussed	Chalk and board method will be used and powerpoint presentation for understanding The interaction between various cells	Students will be asked to focus on the functioning of T cell as opposed to B cells. Certain articles related to these basic concepts will be discussed in groups
V.	Students will understand the importance of regulated immune response. What will happen if the immune response is exaggerated will be explained with examples. The concept of autoimmunity will also be explained	Chalk and board method will be used and supplemented with powerpoint presentation.	Interaction with students will be held in form of some case studies .Quiz will be held.
VI.	Importance of immunity will be highlighted by explaining the importance of vaccines and transplantation of organs.	Chalk and board method will be used and supplemented with powerpoint presentation.	Students will be asked to read articles related to immunity and its intervention in medicine and group presentation on these topics will be encouraged.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Immunity, Innate Immunity, Adaptive Immunity, Antigens, Antibodies, Antibody Diversity, Antigen Processing & Presentation, MHC, Humoral Response, Cell mediated Immunity, Hypersenstivity, Tolerance, Autoimmunity, Vaccines

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES
Nutritional Biochemistry (BCH DSE-1)
Semester - V

1. Course Objective

This course provides students with knowledge and understanding of the characteristics, function, assimilation, distribution and deficiency of macro and micronutrients in the human body. It involves integrated learning between the areas of Biochemistry and Nutrition.

2.1 Course Learning Outcomes

At the end of the course, the students are expected to:

- Critically analyze and evaluate concepts in nutritional biochemistry that are important for an understanding of human nutrition.
- Appreciate the biochemical underpinning of human nutrition in maintaining health.
- Demonstrate understanding of the biochemical basis of essentiality of macro and micronutrients and their nutritional deficiencies.
- Be aware of techniques used in the assessment of nutritional status and nutritional disorders.
- Understand drug nutrient interactions.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to Nutrition and Energy Metabolism **No. of hours: 6**

Defining nutrition, role of nutrients. Unit of energy, biological oxidation of foodstuff. Physiological energy value of foods, SDA. Measurement of energy expenditure, BMR and RMR- factors affecting BMR. Recommended Nutrient Intakes (RNI) and Recommended Dietary Allowances for different age groups.

UNIT II: Macronutrients **No. of hours : 20**

Food sources of carbohydrates, Review functions of carbohydrates. Factors affecting Digestion, absorption and utilization. Glycemic index and glycemic load. Dietary fiber and role of fibre in health. Role of Gut microbiome in maintaining health. Role of pre and probiotics in nutritive health. Essential Fatty Acids; Functions of EFA, RDA, – excess and deficiency of EFA. Dietary implications of fats and oils, Combination ratios of n6 and n3, MUFA, PUFA and SFA Factors affecting Digestion, absorption and utilization. Importance of the following: a) Omega – fatty acids. Omega 3/ omega 6 ratio b) Phospholipids c) Cholesterol in the body d) Mono, Polyunsaturated and Saturated Fatty Acids. Review of functions of proteins in the body, Digestion and absorption. Essential and Nonessential amino acids. Complete protein, Amino Acid Availability, Antagonism, Toxicity, Imbalance, Amino acid complementation and Supplementation in foods. Effects of deficiency. Food source and Recommended Dietary Allowances for different age group. Amino acid pool. NPU, Biological Value, Nitrogen balance. PEM:Marasmus and Kwashiorkor.

UNIT III: Micronutrients: Vitamins **No. of hours : 12**

Vitamin A, D, E, K and dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME), Deficiency. Role of Vitamin A as an antioxidant, in Visual cycle, dermatology and immunity. Role of Vitamin K in Gamma carboxylation. Role of Vitamin E as an antioxidant. Extra-skeletal role of Vitamin D and its effect on bone physiology. Hypervitaminosis. Vitamin C- Dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME); role as cofactor in amino acid modifications. The B Complex vitamins- Dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME); Thiamine -TPP role in metabolism and deficiency disease; Niacin- Metabolic interrelation between tryptophan, Niacin and NAD/ NADP; Vitamin B6-conversion to Pyridoxal Phosphate. Role in metabolism, Biochemical basis for deficiency symptoms; Vitamin B12 and folate - metabolic role, homocysteine cycle, Biochemical basis for deficiency symptoms.

UNIT IV: Micro Minerals and trace elements **No. of hours : 10**

Calcium, Iron and Phosphorus- Distribution in the body digestion, Absorption, Utilization , Transport, Excretion, Balance, Deficiency, Toxicity, Sources, RDA. Iodine, Fluoride, Mg, Cu, Zn, Se, Manganese, Chromium, Molybdenum Distribution in the human body, Physiology, Function, deficiency, Toxicity and Sources

UNIT V: Assessment of Nutritional status **No. of hours : 6**

Direct methods of assessment-Anthropometric measurements; Biochemical assessment; clinical signs; dietary records and nutrient intake. ROS assessment, GTT and glycosylated Hb, Differential diagnosis of B12 and folate.

UNIT VI: Food-drug interactions and Nutraceuticals **No. of hours : 6**

Nutrient interactions affecting ADME of drugs. Drug induced nutrient deficiency: Alcohol, Antibiotics, Anti-malarial drugs. Food as medicine: turmeric, garlic, ginger, cumin, asafoetida

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Anthropometric identifications for nutrition related diseases
2. Blood Lipid profile
3. Determination of oxidative stress: TBARS in serum, antioxidant enzymes in hemolysate/plant sources.
4. Estimation of vitamin in drugs/food/serum.
5. Estimation of minerals in drugs/food/serum.
6. Estimation of glycosylated haemoglobin
7. Determination of nutritive value of foods
8. Case studies on nutritional disorders.

2.3 References

1. Coombs Jr. G. F., (2008). *The vitamins, Fundamental aspects in Nutrition and Health.* Elsevier's Publications. ISBN-13- 978-0-12- 183493-7.
2. Devlin, T. M., (2011). *Textbook of Biochemistry with Clinical Correlations.* John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
3. Mahan, L.K., Strings, S. E., Raymond, J. (2012) *Krause's Food and Nutrition Care process.* Elsevier's Publications. ISBN: 978-1-4377-2233-8.
4. Rosalind Gibson (2005). *Principles of Nutritional Assessment.* Oxford University Press. ISBN: 9780195171693
5. Tom Brody (1999). *Nutritional Biochemistry* (2nd ed). Harcourt Braces. ISBN:9814033251, 9789814033251.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Basic concepts of nutritional biochemistry that are important for an understanding of human nutrition will be learnt.	Chalk and board teaching for basic concepts	Assessment through regular discussion, Quiz and solving numerical problems on energy expenditure
II.	Understand the biochemical basis and nutritional importance of macronutrients. They will learn the importance of gut biome in maintenance of health and the role of dietary fiber in maintaining a good gut microbiome and will understand the concepts of diet composition in governing nutrient assimilation	Power point presentations will be used to teach about essential macronutrients. Discussions will be held to clarify the concepts.	Regular oral question answer sessions in class, case study evaluations and Internal assessment test
III.	Development of understanding of the ADME and essentiality of fat and water soluble vitamins. They will also learn the biochemical mechanisms for the symptoms of vitamin deficiencies and excesses	Chalk and board teaching, power point presentation on essential vitamins and their deficiency disorders, historical perspective on nutritional deficiencies Practical diagnosis of any one vitamin deficiency.	Oral question-answer sessions in class, assessment through test/quiz and case study analysis.
IV	Appreciate the importance of mineral macronutrients with special emphasis on calcium and iron	Black board teaching of the basic concepts and powerpoint presentations on regulation of micromineral homeostasis Practical diagnosis of any one mineral deficiency.	Test and assignment Case study analysis. Power point presentations on chemistry of vitamins.

V	Get acquainted with the techniques used in the assessment of nutritional status and nutritional disorders.	Chalk and board teaching and discussion on case studies bases on anthropometry and biochemical estimations Anthropometric assessment- Practical class. Practical assessment of oxidative stress.	Assessment test and case study evaluation
VI.	Gain knowledge about drug nutrient interactions.	Power point presentation and chalk and board teaching.	Test/quiz on various groups of drugs and their effect on nutrient availability Power point presentations Onnutraceuticals.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Nutrition, macro nutrients, micro nutrients, nutrient assessment, nutrient deficiency

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES
Advanced Cell Biology (BCH DSE-2)
Semester - V

1. Course Objective

The course aims to provide advanced knowledge of the function of cellular organelles, the structure and function of cytoskeleton and its role in motility. The course will also provide details of cellular interaction with cells and tissues around and the molecular regulation of cell growth and cell death. The course will outline the molecular details of the origin of cancer and the diagnosis and treatment.

2.1 Course Learning Outcomes

The learning outcomes will be as follows:

- Students will develop understanding of the principle and application of some of the classical and advanced cell biology techniques
- Students will be able to describe the role of organelles in the secretion of mature proteins and key role of the cytoskeleton in the living cell.
- Students will be able to understand the factors regulating mitosis, meiosis, apoptosis and necrosis. They will also be able to comprehend the role and therapeutic value of stem cells.
- Students will be able to understand the genetic basis of development of cancer, the molecular diagnosis and molecular drugs which are used for chemotherapy.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Advanced Methods in Cell Biology **No. of hours: 6**

Principle and application of ultracentrifugation

UNIT II: Protein Sorting and Secretory Pathway **No. of hours: 16**

Transport of proteins across nuclear envelope; Regulation of nuclear protein import and export. Overview of the endomembrane system; Targeting, modification and sorting of proteins from and into Endoplasmic Reticulum; Synthesis and targeting Mitochondrial protein; Chloroplast Proteins and Peroxisomal proteins; Mechanism of Vesicular Transport; Coat Proteins and Vesicle Budding; Vesicle Fusion; Targeting of Proteins

UNIT III: Cytoskeleton and Cell Motility **No. of hours: 10**

Function and origin of the cytoskeleton; Organization and assembly of Actin Filaments and Myosin; Assembly and organization of Microtubules and Intermediate Filaments; Motor proteins of microtubules and their functions. Cell movement.

UNIT IV: Cell Division and its Regulation **No. of hours: 10**

Overview of the cell cycle; Eukaryotic cell cycle; Events of Mitotic Phase; Cytokinesis; Events of Meiosis And Fertilization; Regulation of Cell Division and Cell Growth;

UNIT V: Cell Death and its Regulation **No. of hours: 8**

Apoptosis and Necrosis, Application of stem cells in health and disease. Hematopoiesis, Embryonic Stem Cells and Therapeutic Cloning.

UNIT VI: Molecular Basis of Cancer Biology **No. of hours: 10**

Development and causes of cancer; Genetic basis of cancer; Oncogenes, Tumor Viruses; Molecular approach to cancer treatment.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Techniques of Plant /Animal Tissue Culture
2. Study of pinocytosis by paramecium under microscopy
3. Calculating viability of bacterial cells after exposure of the bacterial culture to UV rays
4. Preparing temporary mount of nerve cell from mammalian spinal cord
5. Differential centrifugation of cell and validation of separated organelles by enzyme markers
6. Study of cell- cell agglutination by lectin and calculation of haem-agglutination titre.
7. Demonstration of phagocytosis/apoptosis

2.3 References

1. Cooper, G.M. and Hausman, R.E., (2009). *The Cell: A Molecular Approach*.(7th ed.). ASM Press & Sunderland (Washington DC), Sinauer Associates, MA. ISBN:978-0-87893-30.
2. Karp, G., (2010). *Cell and Molecular Biology: Concepts and Experiments* (8th ed.). John Wiley & Sons. Inc. ISBN : 978-1-118-65322-7.
3. Kleinsmith, L. J., Hardin, H., Wayne G., Becker, M. (2009). *The World of the cell* (7th ed.). ISBN-13: 978-0805393934 / ISBN-10: 0805393935.

Additional Resources:

1. Alberts, B., Johnson, A., Lewis, J., and Enlarge, M. (2008). *Molecular Biology of the* Cell. (5th ed.). Garland Science (Princeton), ISBN:0-8153-1619-4 / ISBN:0-8153-1620-8.

2. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell. J., (2012). *Molecular Cell Biology* (7th ed.). W.H. Freeman & Company (New York). ISBN:13:978-14641-0981-2 / ISBN:10: 1-4641-0981-8.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	The students will be given an in-depth understanding of the principles, working, application and limitations of various advanced techniques used in cell biology	Basic concepts will be explained with the help of power point presentations /chalk board teaching along with informative audio-visuals. The students will be taken to prestigious institutes during educational trips to further help them grasp the concepts taught to them in class.	Internal assessment tests and quiz will be conducted. Students will be assigned various topics and will be asked to deliver a power point presentation on the assigned topics.
II.	The students will gain knowledge regarding the roles various organelles in protein sorting in the cell. They will also learn about the mechanisms involved in vesicular transport and cell-cell/cell-virus fusion.	The students will learn to correlate the advanced techniques learnt by them in the previous unit with the organelles learnt in this unit with the help of electron micrograph diagrams of the various organelles of the cell. They will be given an insight into the original experiments conducted by scientists to discover the protein sorting and secretory pathways of the cell. The students will be taught using power point presentations and chalk board teaching.	The students will be assessed by assignments and internal tests. They will be required to identify the various pathways adopted by the proteins for proper folding and reaching correct destination. They will also be tested on their understanding of difference between the various types of vesicular transport as well as steps involved in fusion of cells/cell-virus.
III.	The students will learn about the organization and assembly of the components of the cytoskeleton like the actin and myosin filaments; the microtubules and intermediate as well as the cilia and flagella. They will also learn about the	The students will be taught the basic concepts regarding the various components of the cytoskeleton and their role in cell motility by using power point presentations and chalk board teaching.	The students will be assessed by assignments and internal tests. Tests in the form of quiz will be held and students will mention the characteristics of each of the components of the cytoskeleton. They will also be quizzed about their knowledge on the types of cellular junctions, method of polarization of cell etc.

	various mechanism of action of the factors contributing to cell motility.		
IV	The students will learn the salient features and phases of cell cycle. They will understand the various events that lead to the progression of cell division – both mitosis and meiosis. They will also understand basic differences between the two types of cell division, and the cell types associated with these divisions.	Basic concepts will be explained with the help of power point presentations /chalk board teaching along with informative audio-visuals. The students will observe the various stages of cell division under the microscope, using various samples.	The students will be tested by asking them to prepare slides identify specific stages of cell division observed by them, and its significance in cell division. The students will also be assessed with assignments and internal tests.
V.	Students will learn the basic concept of cell death and the importance of programmed cell death. They will also understand the various types and importance of stem cells along with their application in therapeutic cloning.	Basic concepts will be explained with the help of power point presentations /chalk board teaching along with informative audio-visuals.	Group discussions will be conducted to elucidate the importance of stem cells in therapeutics. The students will also be assessed with assignments and internal tests.
VI.	The students will learn the basic concepts of cancer biology and understand how and why cancer develops in a system. They will also learn about the currently used approaches towards cancer treatment.	Basic concepts will be explained with the help of power point presentations /chalk board teaching along with informative audio-visuals.	Internal assessment tests and quiz will be conducted. Students will be given assignments outlining the various sources of carcinogens in our surroundings. The assignment will also require them to enlist the various food items that are popularly said help prevent cancer and mention scientific evidence if any, to support these claims.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Ultracentrifugation, FACS, FRET, Confocal Microscopy, Electron microscopy, Plant tissue culture, Animal tissue culture, Immunihistochemistry, Cell-Cell fusion, Posttranslational modification of proteins, secretory pathway, endocytosis, phagocytosis, autophagy, Cytoskeleton, Cilia, Flagella, Cell-Cell interaction, Cell matrix interaction, extracellular matrix, mitosis, meiosis, MPF, Apoptosis, Necrosis, Stem cell application, Cancer, Oncogenes, Tumor virus, cancer treatment

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES
Microbiology (BCH DSE-3)
Semester - V

1. Course Objectives

The objective of the course is to trace the history of development of the discipline of Microbiology and to emphasize the existence of the immense diversity in the microbial world and maintenance of microbes under laboratory conditions. The course also aims to make the students aware of both pathogenic as well as beneficial microbes to prepare students for higher education in microbiology-related disciplines.

2.1 Course Learning Outcomes

On successful completion of this paper, students should be able to:

- Identify different microbes
- Perform routine microbiological practices including sterilization, media preparation, maintenance of microbial culture, staining etc.
- Carry out research using microbes.
- Test microbial culture for antibiotic resistance.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: History of Microbiology **No. of hours: 8**

History of development of microbiology as a discipline, Spontaneous generation versus biogenesis, contributions of Anton von Leeuwenhoek, Joseph Lister, Paul Ehrlich, Richard Petri, Charles Chamberland, Edward Jenner, Louis Pasteur, Robert Koch, Martinus W. Beijerinck, Sergei Winogradsky, Alexander Fleming, Elie Metchnikoff and Emil von Behring

UNIT II: Diversity of Microbial world and Microbial Cell organization **No. of hours: 14**

Difference between prokaryotic and eukaryotic microorganisms. General characteristics of different groups: Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Archaea, Algae, Fungi and Protozoa) with emphasis on distribution, occurrence and morphology. Cell-wall: Composition and detailed structure of Gram positive and Gram negative cell walls, mechanism of Gram's staining. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes.

UNIT III: Microbial Nutrition and Growth **No. of hours: 14**

Nutritional types of microorganisms, growth factors, culture media- synthetic and complex, types of media; isolation of pure cultures, growth curves, mean growth rate constant, generation time; influence of environmental factors on growth of microbes: effect of pH, temperature, solute, oxygen concentration, pressure and radiations. Sterilization, disinfection and antiseptics. Use of physical methods (heat, low temperature, filtration, radiation) and chemical agents (phenolics, halogens, heavy metals, sterilizing gases) in microbial control.

UNIT IV: Pathogenicity of Microorganisms and Antimicrobial Chemotherapy
No. of hours: 8

Introduction to pathogenic microbes; Bacteria, Viruses, Algae, protozoa and fungi. General Characteristics of antimicrobial drugs, determining the level of microbial activity: dilution susceptibility test and disc diffusion test. Range of activity and mechanism of action of penicillin, vancomycin and tetracycline.

UNIT V: Food and Industrial Microbiology **No. of hours: 16**

Importance of microbiology in food and industries; Basic design of fermenter, continuous and discontinuous culture. Preparation of fermented food products such as yoghurt, curd and cheese. Preparation of alcoholic beverages like wine and beer. Single cell proteins. Treatment of waste water (Municipal treatment plant) and sewage. Bioremediation and biodegradation.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. To prepare and sterilize the culture media for the growth of microorganisms
2. To perform various culture transfer techniques: Solid to solid (streaking), liquid to solid (spreading), liquid to liquid, solid to liquid and determine CFU/ml
3. To stain bacteria using methylene blue.
4. To perform gram staining
5. To prepare temporary mount of algae (spirogyra)
6. To prepare temporary mount of fungi (Penicillium)
7. Study of different shapes of bacteria, fungi, algae, protozoa using permanent slides/pictographs

2.3 References

1. Chan, M. J., Krieg E. C. S., Pelczar, N. R. (2004) *Microbiology* (5th ed.). McGraw Hill International. ISBN 13: 9780094623206.
2. Willey, J., Sherwood, L., Woolverton, C. (2017). *Prescott's Microbiology* (10th ed.). McGraw Hill international. ISBN 13: 9781259657573.

Additional Resources:

1. Cappuccino J. G., and Sherman N., *Microbiology: A Laboratory manual* (10th ed.). Benajamin/ Cummings. ISBN 13: 9780321840226.

2. Madigan, M. T., Martinko J. M., & Stahl D. A., (2010) *Brock Biology of Microorganisms* (13th ed.). Pearson Education International. ISBN 13: 9780321649638.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be able to understand the historical development and contributions of various scientists in the field of microbiology	Power point presentations and blackboard teaching. General discussion with students about the topic taught to understand their knowledge.	Class test will be taken. Questions related to the topic will be given in the form of assignment
II.	Students will be able to understand the existence and diversity of the microbial world. They will get familiarize with the Gram staining techniques	Power point presentations and blackboard teaching. Hands on experience on gram staining technique during practical classes	Class test will be taken at the end of module. Questions related to the topic will be given in the form of assignment. Students will also be assessed based on their ability to prepare gram-stained slides.
III.	Students will learn about the nutritional requirements of microorganisms. They will also learn about the various physical and chemical methods used for the control of microbial growth.	Blackboard teaching. principle and working of some of the instruments will be explained using online resources. Experience on handling various instruments during practical classes	Students will be assessed by asking oral questions and also assessed during practical classes for the preparation of media and handling of instruments
IV	Students will gain knowledge about pathogenic microbes and characteristic features of antimicrobial drugs.	Blackboard teaching. General discussion with students about the existence of disease causing microbes in our day-today life.	Class test will be taken at the end of module. Assignment will be given to understand the concept of mechanism of action of different antimicrobial drugs.
V.	Students will be able to understand the	Blackboard teaching. Powerpoint presentation and	Students will be evaluated on the basis of

	industrial applications of microbes	oral discussions in the class	presentations and assignments

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Microorganisms, diversity, culture, Pathogenicity, industrial applications

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES
Molecular Basis of Infectious Disease (BCH DSE-4)
Semester - VI

1. Course Objective

The course aims to provide knowledge about various microbial infectious agents that cause diseases in humans, the concepts of treatment and the biochemical basis of mechanism of action and drug resistance for various antimicrobial agents. The course will also provide outline of the various strategies that are employed for preventing infectious diseases and the role of vaccination in eradication of diseases. It will cover the concept of emergence and re-emergence of diseases and idea of bio-terrorism and its impact worldwide. The course will also summarize the significance of hygiene, sanitation, drugs and vaccination in prevention and eradication of infectious diseases.

2.1 Course Learning Outcomes

Upon completion of this course, a student will:

- Understand various classes of pathogens and their mode of action and transmission.
- Be exposed to the molecular basis of treatment, diagnosis and vaccine design strategies for all the diseases listed.
- Gain insight into host immune responses that ensue subsequent to infection.
- Learn the details of diseases such as tuberculosis, AIDS and malaria which are highly prevalent in Indian subcontinent.

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Infectious diseases: an introduction **No. of hours : 7**

Classification of infectious diseases, Nosocomial infections; Patterns of Disease; Measuring infectious disease frequency; Past and present emerging and re-emerging infectious diseases and pathogens. Source, reservoir and transmission of pathogens. Safety measure when working with pathogen biosafety levels, infection and evasion

UNIT II: Strategies for management of infectious diseases **No. of hours : 4**

Role of drugs, vaccines, hygiene and sanitation in prevention, transmission control and treatment of infectious diseases

UNIT III: Diseases caused by bacteria **No. of hours : 20**

Classification of bacterial pathogens based on structure and nutritional requirements; Overview of bacterial virulence factors and host pathogen interactions; detailed study of tuberculosis: History, causative agent, molecular basis of host specificity, infection and pathogenicity, diagnostics, therapeutics and vaccines, drug resistance and implications on public health. Other bacterial diseases - virulence factors, host pathogen interaction, symptoms, diagnosis, vaccines and drugs against - Typhoid, Diphtheria, Pertussis, Tetanus, Botulism Cholera, Anthrax and Pneumonia

UNIT IV: Diseases caused by viruses **No. of hours : 15**

Structure of viruses, Baltimore system for virus classification; Overview of viral virulence factors and host pathogen interactions; detailed study of AIDS: history, causative agent, pathogenesis, diagnostics, drugs; other viral diseases including hepatitis, Influenza (Antigenic shift and antigenic drift), Rabies, Dengue and Polio; Chicken Pox, Herpes Virus

UNIT V: Diseases caused by parasites **No. of hours: 8**

Detailed study of Malaria: history, causative agents, vectors, life cycle, Host parasite interactions, diagnostics, drugs, vaccine development. Other diseases including Leishmaniasis and Amoebiasis, Giardiasis and Trypanosoma infections

UNIT VI: Diseases caused by fungi **No. of hours: 6**

Fungal diseases such as Candidiasis, Sporotrichosis, Aspergillosis and Ring worm: general disease characteristics, medical importance, pathogenesis, diagnosis and treatment

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample
2. WIDAL test as a diagnostic test for typhoid
3. To perform Gram staining of bacterial samples
4. Acid fast staining of non-pathogenic *Mycobacterium*
5. Permanent slides of pathogens: *Mycobacterium tuberculosis*, *Leishmania*, *Plasmodium falciparum*
6. MIC determination using Kirby Bauer / Alamar Blue assay
7. To prepare temporary mount of fungi and identify through staining
8. Research and presentation on current trends in infectious diseases

2.3 References

1. Jawetz, Melnick & Adelbergs (27th ed.), *Medical Microbiology*. McGraw Hill Education. ISBN-10: 0071790314; ISBN-13: 978-007179031.
2. Kenneth J. Ryan, C., George Ray (2010), *Sherris Medical Microbiology: An introduction to infectious diseases*. McGraw-Hill. ISBN-13: 978-0071604024 ISBN-10: 0071604022
3. Prescott, Harley, Wiley, J.M., Sherwood, L.M., Woolverton, C.J. Klien's (2008). Microbiology (7th ed.). Mc Graw Hill International Edition (New York) ISBN: 978-007-126727

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will develop an understanding of important terminologies used in infectious diseases. They will develop an understanding of transmission of pathogens and will gain insight into host immune responses that ensue following infection. They will understand the importance of biosafety equipment for people who work on infectious disease causing pathogens	Revision of concepts covered in the previous class will be done. This will be followed by traditional chalk and board teaching aided with Power Point presentations	Group discussion and quiz will be conducted, and students will be given assignments
II.	Students will learn the strategies used for management of infectious diseases i.e. prevention, transmission control and treatment of infectious diseases	Revision of concepts covered in the previous class will be done. This will be followed by traditional chalk and board teaching aided with Power Point presentations	Class tests will be conducted, and students will be asked to deliver Power Point presentations on the assigned topics
III.	Students will learn classification of bacteria and study various bacterial virulence factors. Students will understand the pathophysiology of the Mycobacterium and study ways to prevent and treat Tuberculosis. They will also learn about various bacterial diseases (Typhoid, Diphtheria, Pertussis, Tetanus Botulism, Cholera, Anthrax, Pneumonia) their molecular mechanisms and intervention strategies	Revision of concepts covered in the previous class will be done. This will be followed by traditional chalk and board teaching aided with Power Point presentations	Group discussion, Quiz will be conducted, and students will be asked to deliver Power Point presentations on the assigned topics
IV	Students will learn about Baltimore classification system of viruses and viral	Revision of concepts covered in the previous class will be done. This	Group discussion, Class tests will be conducted, and students will be given

	virulence factors. They will understand the pathophysiology of the HIV, Influenza and Hepatitis virus and study ways to prevent and treat AIDS, Influenza and Hepatitis. Students will learn about other various viral diseases (Chicken Pox, Herpes, Rabies, Dengue and Polio) their molecular mechanisms, diagnosis and intervention strategies.	will be followed by traditional chalk and board teaching aided with Power Point presentations	assignments and will be asked to give PowerPoint presentations on the assigned topics
V.	Students will learn about various parasitic diseases, host parasite interaction, their molecular mechanisms of infection, diagnosis and intervention strategies	Revision of concepts covered in the previous class will be done. This will be followed by traditional chalk and board teaching aided with Power Point presentations	Quiz, Class tests will be conducted, and students will be asked to deliver Power Point presentations on the assigned topics
VI.	Students will learn about various fungal diseases, their molecular mechanisms, diagnosis and intervention strategies	Revision of concepts covered in the previous class will be done. This will be followed by traditional chalk and board teaching aided with Power Point presentations	Class tests will be conducted, and students will be asked to deliver Power Point presentations on the assigned topics

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Infection, Pathogen, Immune response, Diagnosis, Vaccines, Diseases

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE PAPER
Plant Biochemistry (BCH DSE-5)
Semester - VI

1. Course Objectives

The course aims at providing deep understanding of metabolic processes in plants and the role of different biosynthetic pathways in plant growth and development. The course will also impart basic concepts and applications of plant tissue culture.

2.1 Course Learning Outcomes

Successful completion of this course will provide students with the following learning outcomes:

- Understanding of plant cell structure and organization.
- Concept of the biochemical processes and metabolic pathways specific to plants, including photosynthesis, photorespiration, cell wall biosynthesis, nitrogen fixation and assimilation and plant secondary metabolism.
- Insight on how plants have evolved to cope up with the different stress conditions.
- Knowledge of the basic concepts of plant tissue culture and its application in generating transgenic crops.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to plant cell structure and carbon fixation **No. of hours: 16**

Introduction to Plant cells, Plasma membrane, Vacuole and Tonoplast membrane, Cell wall, Plastids and Peroxisomes. Photosynthesis and Carbon assimilation. Structure of PSI and PSII complexes, Light reaction, Cyclic and non-cyclic photophosphorylation, Calvin cycle and regulation; C4 cycle and Crassulacean acid metabolism (CAM), Photorespiration, Photo inhibition of photosynthesis, Photosynthetic carbon reduction (PCR) cycle, Synthesis of polysaccharides in plants.

UNIT II: Respiration **No. of hours: 12**

Overview of glycolysis, Alternative reactions of glycolysis, Regulation of plant glycolysis, Translocation of metabolites across mitochondrial membrane, TCA cycle, electron transport chain, Alternative NAD(P)H oxidative pathways; Cyanide resistant respiration.

UNIT III: Nitrogen metabolism **No. of hours: 10**

Biological nitrogen fixation by free living and in symbiotic association; Structure and function of the enzyme nitrogenase. Nitrate assimilation: Nitrate and Nitrite reductase. Primary and secondary ammonia assimilation in plants; ammonia assimilation by glutamine synthetase-glutamine oxoglutarate amino transferase (GS-GOGAT) pathway. Seed storage proteins in legumes and cereals.

UNIT IV: Regulation of plant growth and stress physiology **No. of hours: 8**

Introduction to plant hormones and their effect on plant growth and development, Regulation of plant morphogenetic processes by light.Plant stress, Plant responses to abiotic and biotic stresses, Water deficit and drought resistance, Flooding, Temperature stress, Salt stress, Ion toxicity, Pollution stress and potential biotic stress (insects and diseases).

UNIT V: Secondary metabolites and toxins **No. of hours: 8**

Representative alkaloid group and their amino acid precursors, function of alkaloids. Examples of major phenolic groups; simple phenylpropanoids, coumarins, benzoic acid derivatives, flavonoids, tannins and lignin, biological role of plant phenolics, Classification of terpenoids and representative examples from each class, biological functions of terpenoids.

UNIT VI: Plant tissue culture and biotechnology **No. of hours**: **6**

Cell and tissue culture techniques, types of cultures: organ and explants culture, callus culture, cell suspension culture and protoplast culture. Plant regeneration pathways: organogenesis and somatic embryogenesis. Applications of cell and tissue culture and somoclonal variation. Germplasm storage and cryo- preservation. Brief introduction to transgenic plants.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Induction of hydrolytic enzymes proteinases /amylases/lipase during germination
2. Extraction and assay of urease from Jack bean
3. Estimation of carotene/ascorbic acid/phenols/tannins in fruits and vegetables.
4. Separation of photosynthetic pigments by TLC.
5. Culture of plants (explants).

2.3 References

1. Buchann (2015). *Biochemistry and Molecular Biology of plant*. (2nd ed.). I K International. ISBN-10: 8188237116, ISBN- 978047 07 14218
2. Caroline Bowsher, Martin steer, Alyson Tobin (2008). *Plant Biochemistry*. Garland Science. ISBN 978-0-8153-4121-5.
3. Dey, P. M. and J.B. Harborne, J.B., (Editors) (1997). *Plant Biochemistry*. Academic Press. ISBN-10:0122146743, ISBN-13:978-0122146749.

Additional Reading

1. Taiz, L. and Zeiger, E. (2010). *Plant Physiology* (5th ed.). Sinauer Associates Inc. ISBN-13: 978-0878938667, ISBN-10: 0878938664.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be introduced to basic structure of plant cell and roles of different organelles. Students will gain detailed knowledge on the process of photosynthesis. Students will also learn about carbon fixation by Calvin cycle (C3 cycle), C4 cycle and Crassulacean acid metabolism (CAM).	Teaching will be conducted through both black board mode and power point presentation mode. Special lecture will be organized on current aspects of photosynthesis and carbon fixation.	. Preparation of summary of differences of plant cells from cells of various other organisms; Retrieval of original research papers on photosynthesis, carbon assimilation, light reactions and associated topics. They will separate photosynthetic pigments by TLC.
II.	Students will gain insight into the process of respiration in plants with major focus on how it is different from animal respiration. Further, the students will understand the importance of translocation of metabolites across mitochondrial membrane.	Students will be asked to orally revise the previous class before every new class helping them in better understanding.. Teaching will be conducted through both black board mode and power point presentation mode.	. Students will be given assignment on different topics and will be asked to deliver a power-point presentation on the assigned topics.
III.	Students will learn in detail about how biological nitrogen fixation is carried out by free living and symbiotic bacterial associations. Students will gain insight into nitrate and nitrite reductase and their role in nitrate assimilation. This unit will also emphasize on ammonia assimilation by glutamine synthetase-glutamine oxoglutarate amino transferase (GS-GOGAT) pathway in plants.	Classical black board and power point presentation mode will be used for teaching. Videos on the topic will be used for concept building	A written test will be conducted. Students will be assigned the task of retrieving research papers where nitrogen metabolism in plants were engineered. Debate as to whether nitrogen metabolism may be affected by changing environmental conditions.
IV	Students will gain insight of plant hormones and their	Class room lectures, power point presentations,	

	effect on plant growth and development. Students will also understand how plants respond to various abiotic and biotic stresses like water deficit and drought resistance, flooding, temperature stress, salt stress, ion toxicity, pollution stress and potential biotic stress (insects and diseases).	MOOCs/ UGC e-pathshala/ Open education resources to be used. Stress biology is a significant research area in the University and faculties will be invited for lectures.	The applications of stress biology in the generation of transgenic plants resistant to environmental stresses to be reviewed. Interaction with University researchers in the area.
V.	Students will learn about the significance of secondary metabolites and toxins in plants with the help of examples of major phenolic groups; simple phenylpropanoids, coumarins, benzoic acid derivatives, flavonoids, tannins and lignin. It will also help the students understand the biological role of plant phenolics and terpenoids.	Powerpoint presentations, classroom lectures, videos to be utilized.	. Students will be given assignment on topics related to plant secondary metabolites and their biological role and applications. s They will review methods on the identification of such metabolites and estimate some of them in laboratory .
VI.	Students will gain knowledge about basic cell and plant tissue culture techniques and their application in generation of transgenic plants. This will help them learn the concept of organ and explant culture, callus culture, cell suspension culture and protoplast culture. Concepts related to plant regeneration pathways: organogenesis and somatic embryogenesis will be imparted to the students.	Chalk and board teaching, power point presentations, videos on plant tissue culture and biotechnology. Research papers will be discussed.	Internal assessment test will be conducted. Students will learn how to culture explants in laboratories. They will identify transgenic plants in use and their status in India.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Plant cell, photosynthesis, respiration, nitrogen fixation and assimilation, secondary metabolism, stress biology, plant tissue culture.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE PAPER
Advanced Methodologies (BCH DSE-6)
Semester - VI

1. Course Objectives

The objective of the course is to provide students with a sound background of latest techniques used in biochemistry research and to provide them with an understanding of the principles underlying these techniques. The course is designed to impart laboratory skills in the form of practical exercises so that students can apply this knowledge to augment their research acumen and improve their understanding of the subject.

2.1 Course Learning Outcomes

- Students will acquire knowledge about the principles and applications of latest methods used to analyze nucleic acids and proteins.
- Students will learn about the principle and applications of microscopy and various cell biology techniques.
- Students will also be exposed to various methods of labeling DNA, proteins and whole cells and their applications in research.
- The course will also provide them an opportunity for hands-on-experience to develop their laboratory skills expected of any biochemist working in a research lab.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Methods for analysis of nucleic acids **No. of hours :20**

Hybridization methods: Southern blotting, Northern blotting, *In situ* hybridization, Colony hybridization. Binding of nucleic acids with protein: DNA pull down assays, Electrophoretic Mobility Shift Assay (EMSA), DNA footprinting, Primer Extension, Chromatin immunoprecipitation (ChIP), ChIP on ChIP. Gene expression analysis: Reporter assays - example luciferase assay, DNA Microarrays, RNA seq.

UNIT II: Methods for analysis of proteins **No. of hours :20**

Protein-Protein Interaction: Immunoprecipitation, Co-Immunoprecipitation (Co-IP), Pull down assays, Yeast two hybrid, Protein fragment complementation assay, Western blotting, Far western blotting, Protein microarrays, ELISA. Protein Separation: Isoelectric focusing, 2D protein gel electrophoresis, 2D-DIGE, Pulse field Electrophoresis; Structural Analysis: Mass Spectrometry, MS/MS, LC/MS.

UNIT III: Microscopy based methods **No. of hours : 6**

Fluorescence microscopy, Scanning electron microscopy, Transmission electron microscopy, Confocal microscopy

UNIT IV: Cell Biology techniques **No. of hours : 8**

Cell culture and transfection, Immunohistochemistry, Immunofluorescence, Flow cytometry, FACS, TUNEL assay, Non-invasive scanning of soft tissue

UNIT V: Labeling methods **No. of hours : 6**

Radioactive and Non-radioactive labeling: DNA, Proteins, Whole cells, Fluorescent labeling. DNA, Proteins, bacteria, living cells; Metabolic labeling, Pulse chase analysis

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Western Blotting
2. Southern hybridization
3. Labeling DNA with biotinylated primers using PCR
4. EMSA (virtual lab)
5. Protein Pull down assay
6. Virtual lab on Microarray profiling or 2D-DIGE

2.3 References

1. Ausubel, F.M. et al. (2012). *Current protocols in molecular biology*. New York: John Wiley & Sons.
2. Bisen, P. S., & Sharma, A. (2013). *Introduction to instrumentation in life sciences*. Boca Raton: CRC Press.
3. Bonifacino, J. S., Dasso, M., Lippincott-Schwartz, J., Hartford, J. B., & Yamada, K. M. (Eds.). (1999). *Current protocols in cell biology*. New York: John Wiley.
4. Coligan, J. E., Dunn, B. M., Ploegh, H. L., Speicher, D. W., & Wingfield, P. T. (1995). *Current protocols in protein science*. New York: John Wiley & Sons.
5. Coligan, J. E. et al. (1991). *Current protocols in immunology*. New York: John Wiley & Sons.
6. Fu, H. (Ed.). (2004). *Protein-protein interactions: Methods and protocols* (Vol. 261). Totowa, NJ: Humana.
7. Levine, S., & Johnstone, L. (2008). *The ultimate guide to your microscope*. New York: Sterling Pub.
8. Schimmel. (2013). *Biophysical Chemistry*. MacMillan Higher Education.
9. Wilson, K., & Walker, J. (Eds.). (2010). *Principles and techniques of biochemistry and molecular biology* (7th ed.). Cambridge: Cambridge Univ. Press.

Additional Resources

1. Golemis, E., & Adams, P. D. (2005). *Protein-protein interactions: A molecular cloning manual* (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Green, M. R., & Sambrook, J. (2012). *Molecular cloning: A laboratory manual* (4th ed., Vol. 1-3). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Sheehan, D. (2010). *Physical biochemistry: Principles and applications* (2nd ed.). Chichester: Wiley-Blackwell.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	The student will learn about the methods used in analysis and manipulation of nucleic acid	Classroom teaching with visual aids, power point presentations, videos, discussions on applications	Quizzes, assignments and analytical problem solving questions
II.	The student will understand about the various techniques involving protein-protein interactions, their separation, and structural characterization	Classroom teaching with visual aids, power point presentations, experimental data from journals, discussions	Assignments, class tests, analytical questions. Students will be asked to retrieve papers on protein-protein interactions.
III.	The students will get familiar with microscopy based techniques and their application	Presentations, classroom teaching, audio and visual aids, trip to a facility. MOOCs will be used.	Assignments, class tests, class presentations, Mid-term assessment
IV	The students will understand the basics and application of various techniques in the field of cell biology	Powerpoint presentations, trip to a facility to show instruments, audio& visual aids. Special lecture will be arranged by expert in cell biology techniques.	Assignments, class tests, class presentations
V.	The students will learn about the different ways to label cells, microbes, proteins and DNA	Classroom teaching, presentations, discussions to learn how these methods are applied all the previous units	Assignments, class tests, presentations on applications etc. Internal assessment tests will be conducted

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Southern Blotting, Colony hybridization, DNA footprinting, EMSA, Western Blotting, Immunoprecipitation, Pull down assay

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Biomolecules (BCH GE-1)
Semester - I

1. Course Objectives

The objective of the course is to provide students with an understanding of biomolecules, the basic building blocks that are vital for various life forms, focusing on their key properties, biological roles and functions. The course also aims to outline organic and physical aspects of biomolecules.

2.1 Course Learning Outcomes

- Students will acquire knowledge about structure and function of proteins, RNA, DNA, carbohydrates and co-enzymes
- The course will provide an understanding of how structure of biomolecules determine their chemical properties
- Students will develop understanding of biochemistry at atomic level and appreciate the biological importance of each biomolecule

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Biomolecules in their cellular environment **No. of hours : 7**

The cellular basis of life, structure and function of a cell and its subcellular components (eukaryotes, prokaryotes); Physical properties and structure of water molecule, pH, Buffers, biological buffer systems (body fluids and their principal buffers)

UNIT II: Amino Acid and Peptides **No. of hours : 11**

Introduction, general nature of amino acids, classification of amino acids, importance of amino acids, modified and standard amino acids, physical and optical properties of aminoacids, ionization of amino acids, buffering of amino acids, peptide bond, biologically important peptides. Introduction to chromatography, separation of amino acid by paper chromatography

UNIT III: Carbohydrate Chemistry **No. of hours : 11**

Introduction; Definition, classification and functions of carbohydrates, monosaccharides, disaccharides, polysaccharides, homo polysaccharides, hetero polysaccharides; Structure of glucose, isomerism; keto aldo, D-and L- isomerism, optical isomerism, epimerism, anomerism, Mutarotation, chemical properties of monosaccharides, action of strong acids, alkalis, oxidation, reduction, osazone formation glycoside formation; Derivatives of monosaccharides, phosphoric acid ester, amino sugar, deoxy sugar, sugar acids, sugar alcohols, disaccharides maltose, lactose, sucrose. Homo polysaccharides - starch, glycogen, cellulose, dextrin; Hetero polysaccharides - types of glycosoaminoglycans and functions of glycoproteins

UNIT IV: Chemistry of Lipids **No. of hours: 11**

Introduction; Definition, classification and functions of lipids; Fatty acids; Essential fatty; acids; Reactions of lipids; Triacylglycerol or neutral fat; phospholipids glycolipids; cholesterol; Eicosaanoids; prosatglandins; lipoprotein

UNIT V: Chemistry of Nucleic Acid **No. of hours : 11**

Introduction, nucleic acid, nucleotide, biologically important nucleotides, synthetic analogues of nucleotides or antimetabolites; DNA structure and function; Types of DNA; Organization of DNA; RNA structure and function

UNIT VI: Vitamins and Coenzymes **No. of hours : 8**

Definition and classification of vitamins, water soluble vitamins, fat soluble vitamins, occurrence and nutritional role. Coenzymes and their role in metabolism. Metal ion containing biomoleculeus (heme, porphyrins and cyanocobalamine) and their biological role

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1 Safety measures in laboratories.
2. Preparation of normal and molar solutions.
3. Preparation of buffers.
4. Determination of pKa of acetic acid and glycine.
5. Qualitative tests for carbohydrates, and nucleic acids.
6. Separation of amino acids/ sugars/ bases by thin layer chromatography

2.3 References

1. Devlin, T. M., (2011). *Textbook of Biochemistry with Clinical Correlations.* John Wiley & Sons, Inc. (New York). ISBN: 978-0-4710-28173-4.
2. Nelson, D.L. and Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No	Course Learning Outcomes	Teaching & Learning Activity	Assessment Tasks
I	Student will learn the fundamental concepts of cellular basis of life, cellular structure of prokaryotes and eukaryotes. They will also learn the role of water in design of these molecules.	Chalk and board method will be used and power point presentation for depicting the structure of cells and role of water in design of these molecules.	Students will be asked to correlate the importance of these molecules from their cells by take home assignments.
II	Students will gain insight into basic structures, chemistry and property of amino acids along with derivatives of amino acids. They will be introduced to chromatography	Chalk and board method will be used. Power point presentation for understanding these structure and their role.	MCQ based assignments will be given to students to check their understanding.
III	Understanding of the basic chemistry, structure and classification of all types carbohydrates, along with their biological role.	Chalk and board method and power point presentation will be used for describing these structures distribution &their biological role.	MCQ based assignment will be given to students. Structures will be shown for them to identify the type and class of carbohydrate
IV	Students will learn about the basic building blocks of lipids and the different categories of lipids in the body with main emphasis being on understanding their structure. They will also be exposed to some aspects of function of the different lipids in the body including their role as cofactors, pigments and signaling molecules.	Learning of individual students will be conducted by a traditional chalk and board method and supported by power point slides wherever appropriate.	Multiple choice questions, take home assignments and regular Q&A sessions during class.
V	Students will learn the basic aspects of the structure of DNA and RNA along with unusual structures of DNA. Students will also be made aware of the other roles that nucleotides can play in the body.	Regular question answer sessions in the class to encourage student participation. Regular chalk and board teaching will be used.	Students' knowledge will be assessed via regular quizzes and take home assignments

VI	Students will learn about the nutritional roles of all water soluble and lipid soluble vitamins in the body along with their occurrence. They will also be made aware of how vitamins are crucial in metabolism of the body.	Students will be communicated to mainly using chalk and board method with occasional support taken from structures projected on transparencies or power point slides	Assessment of the student learning will be done by home exams, multiple choice quizzes and take home assignments. They will review research papers as well.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Buffer, Amino Acids, Glucose, Disaccahrides, Polysaccharides, Lipids, Nucleic Acids, Vitamins, Chromatography

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Techniques in Biochemistry (BCH GE-2)
Semester – I / II

1. Course Objectives

The objective of the course is to introduce various techniques to students that are used in biological research as well as to provide them with an understanding of the underlying principles of these techniques. The emphasis is also on experimental skills in the form of practical exercises so that students can apply this knowledge to improve their understanding of the subject for better execution of these techniques.

2.1 Course Learning Outcomes

- Students will acquire knowledge about the principles and applications of spectrophotometric and chromatography techniques used in a biochemistry lab.
- Students will learn about the principle and application of electrophoresis, centrifugation techniques, cell culture and microscopic techniques.
- It will also give them an opportunity to get hands on experience to develop their experimental skills expected from any biochemist working in a research lab.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS:60**

UNIT I: Spectroscopic Techniques **No. of hours: 15**

Electromagnetic radiation, interaction of radiation with biomolecules, principle of UV-visible absorption spectrophotometry, Lambert's Law, Beer's Law, working of a spectrophotometer. Applications of UV-visible absorption spectrophotometry in biochemistry. Fluorescence spectrophotometry: Phenomena of fluorescence, intrinsic and extrinsic fluorescence, applications of fluorescence in biochemistry.

UNIT II: Chromatography **No. of hours: 15**

Preparation of sample, different methods of cell lysis, salting out, dialysis. Introduction to chromatography. Different modes of chromatography: paper, thin layer and column. Preparative and analytical applications. Principles and applications of: Paper Chromatography, Thin Layer Chromatography, Ion Exchange Chromatography, Molecular Sieve Chromatography, Affinity Chromatography.

UNIT III: Electrophoresis **No. of hours: 12**

Basic Principle of electrophoresis, Paper electrophoresis, Gel electrophoresis, discontinuous gel electrophoresis, PAGE, SDS-PAGE, Native gels, denaturing gels, agarose gel electrophoresis, buffer systems in electrophoresis, electrophoresis of proteins and nucleic acids, protein and nucleic acid blotting, detection and identification (staining procedures), molecular weight determination, isoelectric focusing of proteins.

UNIT IV: Centrifugation **No. of hours: 8**

Principle of centrifugation, basic rules of sedimentation, sedimentation coefficient. Various types of centrifuges, low speed centrifuge, high speed centrifuge and ultracentrifuge, types of rotors. Application of centrifugation, differential centrifugation, density gradient centrifugation- zonal and isopycnic.

UNIT V: Microbiological/Cell culture techniques **No. of hours: 5**

Types of media, selective and enrichment media, sterilization methods, bacterial culturing, CFU determination, growth curves, Generation/doubling times, cell counting, viable and non-viable. Growth and maintenance of cultures, biosafety cabinets, CO_2incubator. Staining procedures, plating and microtony.

UNIT VI: Microscopy **No. of hours: 5**

Principle of light microscopy, phase contrast microscopy, fluorescence microscopy. Permanent and temporary slide preparation, histology and staining.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Verification of Beer's Law
2. Estimation of proteins by Biuret/Lowry method
3. Separation of amino acid acids by TLC/paper chromatography
4. To perform agarose gel electrophoresis
5. To isolate mitochondria by differential centrifugation
6. Visualization of cells by methylene blue

2.3 References

1. Boyer, R.F. (2012). *Biochemistry Laboratory: Modern Theory and Techniques* (6th ed.). Boston, Mass: Prentice Hall. ISBN-13: 9780136043027.
2. Plummer, D. T. (1998). *An Introduction to Practical Biochemistry*. (3rd ed.). Tata McGraw Hill Education Pvt. Ltd. (New Delhi). ISBN: 13: 9780070994874 / ISBN:10: 0070994870.
3. Wiley, J.M., Sherwood, L.M., Woolverton, C.J. (2017). *Prescott's Microbiology*. (10th ed.). McGraw Hill Higher Education. ISBN13: 9781259657573.
4. Wilson, K., Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*, (7th ed.). Cambridge University Press. ISBN 9780521516358.

Additional Resources:

1. Cooper, T. G., (2011). *The Tools of Biochemistry* (2nd ed.). Wiley-Interscience Publication (New Delhi). ISBN: 13:9788126530168.

2. Freifelder, D. (1982). *Physical Biochemistry: Applications to Biochemistry and Molecular Biology* (2nd ed.). W.H. Freeman and Company (New York), ISBN: 0716713152 / ISBN:0716714442.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will learn about the principle and applications of spectrophotometry and flourimetry.	Teaching using chalk and board; Oral discussion sessions in the class. Powerpoint presentations.	Problems will be assigned related to Beer's Law and Lambert's Law to test the understanding of students.
II	Students will learn the principle of various chromatographic techniques like gel filteration, Ion exchange.	Previous classes will be revised. Group discussion sessions in the class. Powerpoint presentations.	Practical exercises are designed whereby the students get hands on experience with these chromatography techniques.
III	Students will learn about electrophoretic techniques, their principle and applications in analyzing proteins and nucleic acids	Oral discussion sessions in the class. Chalk and board teaching.	Various analytical problems will be assigned to students related to electrophoretic separation.
IV	Students will learn about the basic rules of sedimentation, various types of centrifuges and rotors.	Revision of the previous classes for a better understanding of the students. Demonstration of various centrifuges. Chalk and board teaching.	Demonstration with the help of centrifuges and rotors to improve their understanding.
V	Students will learn and understand the different cell culture and microbiological techniques used in biochemistry.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class	Various analytical problems will be assigned to students related to cell counting.
VI	Students will learn about various microscopes and slide preparation, histology and staining techniques.	Group discussion sessions will be held in the class along with powerpoint presentations	Various analytical problems will be assigned to students related to working of microscope.

4. Keywords

Spectrophotometry, Chromatography, Proteins, Nucleic Acids, Centrifugation and Electrophoresis

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Proteins and Enzymes (BCH GE-3)
Semester – II / III

1. Course Objectives

The objective of this course is to provide overview of protein biochemistry and enzymology to undergraduate students with diverse science backgrounds, since proteins and enzymes are the most versatile functional entities in life with applications in various life sciences research as well as in industry and biomedicine. The biochemical, structural, functional and aspects of interaction of proteins and enzymes will be introduced in this course.

2.1 Course Learning Outcomes

On successful completion of the course students will be:

- Familiar with unique features and characteristics of proteins and enzymes and their applications in research, medicine and industry.
- Aware of the relationship between three-dimensional structure of proteins and enzymes and their functions.
- Able to comprehend the basic mechanism of action of enzymes and their remarkable regulation
- Aware of the principles of protein isolation, purification and characterization
- Able to gain hands-on-experience in handling proteins and enzymes from various sources, thus improving their ability of learning and imbibing the basic concepts.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to proteins and their structural organization **No. of hours :10**

Amino acids and their properties. Peptides and their biological significance - hormones, antibiotics and growth factors. Diversity of proteins and their functions. Protein sequence - Edman degradation. Solid phase peptide synthesis. Organization of protein structure - primary, secondary, tertiary and quaternary structures. Conjugated proteins, multimeric proteins and metalloproteins. Bonds in protein structures - covalent and non-covalent. Dihedral angles. Ramachandran map, Secondary structure - helices, sheets and turns.

UNIT II: Three-dimensional structures and protein folding **No. of hours: 12**

Characteristics of tertiary and quaternary structures. Motifs and domains. Structure-function relationship in proteins. 3D structures of myoglobin and hemoglobin. Oxygen binding curves, influence of pH and effector molecules. Concerted and sequential models for allosteric proteins. Hemoglobin disorders. Protein folding - denaturation and renaturation. Role of chaperones. Protein misfolding and aggregation diseases.

UNIT III: Isolation, purification and analysis of proteins **No. of hours: 8**

Ammonium sulphate fractionation, centrifugation dialysis. Ion-exchange chromatography, molecular sieve chromatography, affinity chromatography. HPLC and FPLC. Gel electrophoresis: SDS-PAGE, IEF and 2-D electrophoresis.

UNIT IV: Introduction to enzymes, their characteristics and kinetics **No. of hours: 12**

Nature of enzymes - protein and non-protein (ribozyme, abzymes). Cofactor and prosthetic group, apo- and holo-enzymes. Features of enzyme catalysis. Classification of enzymes and nomenclature. Fischer's lock & key and Koshland's induced fit hypothesis. Enzyme specificity. Enzyme kinetics- Michaelis-Menten equation, Lineweaver-Burk plot. Determination of K_m, V_{max}, K_{cat}. Factors affecting enzyme activity. Enzyme inhibition- Reversible (competitive, uncompetitive, non-competitive) and irreversible inhibition. Mechanism based inhibitors.

UNIT V: Mechanism of enzyme action and enzyme regulation **No. of hours: 10**

General mechanisms of action. Acid-base and covalent catalysis (chymotrypsin, lysozyme). Metal activated enzymes and metalloenzymes. Allosteric regulation and feedback inhibition (ATCase). Reversible covalent modification (glycogen phosphorylase). Proteolytic cleavage-zymogen. Multienzyme complex. Coenzymes.

UNIT VI: Applications of enzymes **No. of hours: 8**

Isoenzymes. Applications of enzymes in research. Application of enzymes in diagnostics (SGPT, SGOT, creatine kinase), Enzyme immunoassay (HRP), Enzyme therapy (Streptokinase). Enzyme immobilization and its applications. Industrial applications.

PRACTICALS

CREDITS: 2 **TOTAL HOURS:60**

1. Estimation of proteins by Biuret and Lowry methods
2. Ammonium sulphate fractionation of crude homogenate from germinated mung beans
3. Enzyme activity assay (acid phosphatase)
4. Progress curve of enzyme
5. Effect of pH / temperature on enzyme activity
6. Determination of K_m and V_{max} using Lineweaver-Burk plot.

2.3 References

1. Cooper, T. G. (2011). *The Tools of Biochemistry* (2nd ed.). Wiley-Interscience Publication (New Delhi). ISBN: 13:9788126530168.
2. Nelson, D.L. and Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.

3. Nicholas, C.P., Lewis, S. (1999). *Fundamentals of Enzymology* (3rd ed.). Oxford University Press Inc. (New York), ISBN: 0 19 850229 X.
4. Sheehan, D. (2009). *Physical Biochemistry* (2nd ed.). Wiley-Blackwell (West Sussex), ISBN: 9780470856024 / ISBN: 9780470856031.
5. Voet, D., Voet, J., Pratt, C. (2013). *Biochemistry* (4th ed.) Wiley & Sons, Inc. (New Jersey). ISBN: 978-1-11809244-6.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will gain knowledge about the building blocks of proteins i.e. amino acids and understand about the structural organization of proteins.	Students will be taught using power point presentations, chalk and board. In class oral discussion sessions will be conducted.	Oral questions will be asked in the class. Assignment and tests will be given.
II	Students will understand about the characteristics of tertiary and quaternary structures, 3D structure of Hemoglobin and Myoglobin. They will also understand the concept of protein folding (denaturation and renaturation).	They will be taught using power point presentations, chalk and board. The use of E-learning through online Web and Video courses will be included.	Internal assessment will be done on the basis of quiz and class tests.
III	Students will acquire knowledge about the basic concepts of various techniques used for isolation, purification and analysis of proteins.	Students will be taught using chalk and board. A visit to a Research Lab. for the demonstration/ hands-on-experience of protein purification techniques will be planned to enhance their ability of learning and imbibing the basic concepts.	Students will be assigned different techniques and will be asked to deliver a power point presentation. Various analytical problems will be assigned to students related to purification of proteins.
IV	Students will learn about enzyme catalysis, role of coenzymes, cofactors and different aspects of enzyme kinetics. They will understand about different types of enzyme inhibitors, role of drugs as	They will be shown power point presentations and will be taught using chalk and board. The use of E-learning through online Web and Video courses will be included for the	Regular question- answer sessions in class will be conducted. Internal assessment will include problems/ numericals based on enzyme kinetics.

	enzyme inhibitors and the respective mechanism.	better understanding of the enzyme kinetics.	
V	Students will understand the basic mechanism of enzyme action and enzyme regulation.	Students will be shown power point presentations and will be taught using chalk and board. Oral discussion sessions in the class will be conducted.	They will be assessed on the basis of assignments and class tests.
VI	Students will learn about diverse applications of enzymes in research, diagnostics, therapy and Industry.	Teaching using chalk and board will be done. Oral discussion sessions in the class will be conducted.	Students will undergo internal test for the syllabus covered in Unit 1-V and their answers will be discussed in the following class. Quiz will be conducted. Various analytical problems will be assigned to students based on enzyme applications.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Proteins, Enzymes, Protein structure, Protein folding, Enzyme kinetics, Enzyme regulation

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Biochemical Correlations of Diseases (BCH GE-4)
Semester – II / IV

1. Course Objective

This course provides students with knowledge and understanding of various human diseases. It will introduce the concepts of a well-balanced diet, healthy lifestyle, biochemical basis of diseases, treatment strategies, mechanism of action of drugs and drug resistance against various antimicrobials. The course also aims to outline the various strategies that are employed for preventing infectious and non-infectious diseases.

2.1 Course Learning Outcomes

- Students will develop understanding about the importance of balanced diet, regular exercises and healthy lifestyle.
- Students will gain insight into various disorders associated with imbalanced diet and poor lifestyle.
- Students will learn various strategies employed for preventing various human diseases.
- Students will understand the molecular basis of microbial pathogenicity, drug resistance and implications in public health management.
- Students should be able to handle and solve analytical problems related to theory classes.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Inherited metabolic diseases **No. of hours: 8**

Alkaptonuria, Phenylketonuria, Glycogen storage diseases: Von Gierke, Cori and McArdle, Lipid storage diseases: Gauchers diseases, Niemann-Pick disease, SCID: Adenosine Deaminase deficiency.

UNIT II : Nutritional deficiency and lifestyle based diseases **No. of hours: 16**

Kwashiorkar, Marasmus, Beri-beri, Scurvy, Pellagra, Anaemia, Night blindness, Rickets, Osteomalacia, Osteoporosis, Obesity, Cardiovascular diseases, Atherosclerosis, Diabetes Mellitus-II, Inflammatory Bowel Disease (IBD).

UNIT III: Hormonal imbalances **No. of hours : 8**

Hormonal imbalances leading to disease: Diabetes Insipidus, Acromegaly, Gigantism, Dwarfism, Goitre, Cretinism, Cushing and Conn’s syndrome, Addison’s disease.

UNIT IV: Autoimmune diseases **No. of hours: 8**

Concepts in immune recognition-self and non-self-discrimination, organ specific autoimmune diseases-Hashimoto's thyroiditis, Graves' disease, Myasthenia Gravis, Diabetes Melitus-I, Systemic diseases: Systemic lupus erythematosus (SLE), Rheumatoid arthritis.

UNIT V: Diseases caused due to misfolded proteins **No. of hours: 6**

Alzheimer's, Huntington's diseases, Kuru, Creutzfeldt-Jakob disease, Sickle Cell anaemia, Thalassemia.

UNIT VI: Infectious diseases **No. of hours: 16**

Viral infection: Polio, Measles, Mumps, influenza, HIV. Bacterial infections: Tetanus, Diphtheria, Tuberculosis, Typhoid, Cholera. Protozoan: Malaria and Trypanosomiasis. Parasitic infections: Leishmania.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Determination of blood Lipid Profile: Triglyceride, Cholesterol
2. Anthrompometric measurements: BMI, Waist/Hip Ratio, Mid Arm Muscle Area (MAMA), Mid Arm Area (MAA).
3. Haemoglobin estimation
4. Blood pressure measurement
5. Calcium estimation in serum
6. Estimation of blood glucose

2.3 References

1. Berg, J.M., Tymoczko, J. L., Stryer, L. (2012). *Biochemistry* (7th ed.). W.H Freeman and Company (New York).
2. Coico, R., Sunshine, G. (2009). *Immunology: A Short Course* (6th ed.). John Wiley & Sons, Inc (New Jersey). ISBN; 978-0-470-08158-7.
3. Devlin, T. M., (2011). *Textbook of Biochemistry with Clinical Correlations.* John Wiley & Sons, Inc. (New York). ISBN: 978-0-4710-28173-4.
4. Prescott, Harley, Wiley, J.M., Sherwood, L.M., Woolverton, C.J. (2008). *Klein's Microbiology*. (7th ed.). Mc Graw Hill International Edition (New York) ISBN: 978-007-126727.
5. Snustad, D.P., Simmons, M.J. (2012). *Genetics* (6th ed.). John Wiley & Sons. (Singapore) ISBN: 978-1-118-09242-2.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	The students will understand the concepts of metabolism of macromolecules and the diseases related to metabolic errors. Biochemical basis of diseases related to inherited metabolic disorders will also be learned.	Traditional chalk and board method and illustrations through powerpoint presentations. Discussion of case studies. Estimation of Glucose, Calcium and Blood pressure measurement will be taught in the practicals.	Students will be assigned the task of identifying examples of abnormal enzymes that directly relate to each feature of metabolic disorders. A host of characteristics and features will be provided to students and they will need to match them with the type of metabolic disorder. They will encouraged to participate in group discussions related to topics thought in class.
II.	Develop understanding of the importance of balanced diet, regular exercises and healthy lifestyle and disorders associated with imbalanced diet and poor lifestyle. Appreciate the importance of micronutrients and disorders associated with deficiency of minerals and vitamins The students will also learn about life style disorders.	Explaining each topic through power point presentations / chalk and board teaching. Discussion of case studies.	Group discussions and class tests will be held. Assignments on classification of diseases in various macromolecule and micromolecule deficient disorders. Signs and symptoms of diseases will be provided and students will be asked to match them with the type of nutrient disorders. Students will also be given assignments on matching the symptoms with the diseases.
III.	Learn about role of hormones in our daily life and gain insight into various diseases associated with hormonal imbalance.	Class teaching using chalk and board and power point presentations.	Students will be given assignments to match symptoms with the correct disease/ disorders. Group discussions and Tests will be held.
IV	The students will learn about induction of an appropriate immune response and the	Traditional chalk and board method with powerpoint presentations. Few case studies will also	Pre-lecture quiz to evaluate student's understanding of previous lecture. Signs and

	associated disorders, also understand the concept of immune recognition - self and nonself.	be discussed.	symptoms of diseases will be provided and students will be asked to classify them in various types of autoimmune diseases.
V.	Understand the significance of appropriate folding of proteins and the diseases caused due to misfolding of proteins.	Illustrations through power point presentations and through regular chalk and board method. Discussion of case studies.	Group discussions. Quiz, Assignments. Signs and symptoms of diseases will be provided and students will be asked to classify them in diseases caused by misfolding of proteins. Internal assessment test.
VI.	Gain knowledge about various microbial infectious agents that cause diseases in humans. Students will gain insight into host immune responses that ensue following infection.	Traditional chalk and board method with powerpoint presentations.	Pre-lecture quiz to evaluate student's understanding of previous lecture. Assessment tests (end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a powerpoint presentation on the assigned topics.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Lifestyle and metabolic disorders, nutritional deficiency, hormonal disorder, autoimmunity and infectious diseases.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Intermediary Metabolism (BCH GE-5)
Semester - III

1. Course Objectives

The objective of this course is to provide the students an understanding of the major metabolic pathways associated with biomolecules within a cell and their regulation. It will also provide knowledge about the possible correlation between various metabolic pathways.

2.1 Course Learning Outcomes

At the end of the course, the students will be able to:

- Understand the basics of metabolic pathways
- Outline the pathways involved in catabolism and biosynthesis of glucose.
- Describe the mechanism of ATP synthesis.
- Understand the biosynthesis and degradation of glycogen
- Comprehend the metabolism of fatty acids, amino acids, and nucleotides
- Develop an understanding of metabolic integration

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Glycolysis and gluconeogenesis **No. of hours: 12**

Nature of metabolism. Role of oxidation and reduction and coupling of these. ATP as energy currency. Glycolysis a universal pathway, fructose and galactose oxidation, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis. Pentose phosphate pathway, importance of various pathways and their regulation

UNIT II: Citric acid cycle and oxidative phosphorylation **No. of hours: 12**

Pyruvate dehydrogenase complex, oxidation of acetyl CoA, amphibolic role, regulation and glyoxylate pathway. The respiratory chain in mitochondria, proton gradient powering ATP synthesis, glycerol-3-phosphate and malate-aspartate shuttle, regulation of oxidative phosphorylation.

UNIT III: Glycogen metabolism **No. of hours: 8**

Glycogenolysis, phosphorylase regulation, role of epinephrine and glucagon for glycogenolysis, glycogenesis; reciprocal regulation of glycogenesis and glycogenolysis. Diseases associated with the abnormal carbohydrate metabolism.

UNIT IV: Fatty acid and amino acid degradation **No. of hours: 12**

TAG as energy source, β oxidation of fatty acids in mitochondria and peroxisomes, ketone bodies. Fatty acids activation, regulation of fatty acid oxidation, Protein degradation to amino acids, Role of essential and non-essential amino acids in growth and development. Protein calorie malnutrition - Kwashiorkar and Marasmus, urea cycle, feeder pathways into TCA cycle. Nitrogen fixation. Diseases associated with the abnormal metabolism.

UNIT V: Nucleotide metabolism **No. of hours: 10**

Biosynthesis - de novo and salvage pathways, regulation of nucleotide synthesis by feedback inhibition, degradation and excretion. Diseases associated with the abnormal metabolism

UNIT VI: Integration of metabolism **No. of hours: 6**

Brief role of hormones - insulin, glucagon; metabolic shifts to provide fuel to brain during fasting and starvation, Increase in gluconeogenesis and muscle protein breakdown.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Estimation of blood glucose
2. Demonstration of alcohol fermentation by yeast.
3. Estimation of serum urea.
4. Estimation of serum uric acid.
5. Estimation of serum creatinine

2.3 References

1. Berg, J.M., Tymoczko, J.L., Stryer L., (2012) *Biochemistry*7th ed., W.H. Freeman and Company (New York); ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4.
2. Campbell, M.K., Farrel, S.O. (2012) *Biochemistry*7th ed, S.O. Brooks/Cole, Cengage Learning (Boston); ISBN: 13:978-1-111-42564-7 ISBN:10:1-4292-2936-5.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Understanding the concept of metabolism. Understand Glycolysis, gluconeogenesis and Pentose phosphate pathway and their regulation.	Traditional chalk & board method with power-point presentations.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts.

II.	Understand the citric acid cycle and ATP synthesis by oxidative phosphorylation.	Revision of the previous classes will be conducted. Teaching will be through traditional chalk & board method and power-point presentations	Pre-lecture quiz to evaluate students understanding of previous lecture. Internal assessment tests will be conducted.
III.	Have knowledge about glycogenolysis and glycogenesis and their reciprocal regulation	Group discussions will be held on various topics of this unit. Blackboard teaching as well as powerpoint presentations will be conducted.	Home assignments and MCQ based questions will be given to students.
IV	Understand the β-oxidation of fatty acids and its regulation.	Traditional chalk & board method with power-point presentations. Oral question-answers will be held.	Pre-lecture quiz to evaluate students understanding of previous lecture. Students will be asked to deliver presentations and will be assessed on that.
V.	Understand de novo and salvage pathways of nucleotide Biosynthesis and Degradation.	Oral revision of the previous classes will be conducted. Teaching will be through traditional chalk & board method with power-point presentations.	Internal assessment test and crossword puzzles will be given to students for their evaluation.
VI.	Understand the concept of metabolic integration.	Overview of all the metabolic pathways will be discussed along with group discussions. Traditional chalk & board method with power-point presentations.	A continuous evaluation based on their class response will be made. End term examination evaluation. MCQ based questions.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Glycolysis, *De novo* salvage pathway, TCA, catabolism, anabolism, integrative pathways, nucleotide metabolism, beta oxidation, glycogen metabolism, gluconeogenesis.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Biochemical Applications in Forensics (BCH GE-6)
Semester – III / IV

1. Course Objectives

The course aims to provide an understanding of the applications of biochemistry in forensic sciences through analysis of evidences, which will help students develop analytical and problem solving skills for real life situation. The course will keep abreast with all recent developments and emerging trends in forensic science thus helping interested students take up forensic science as future course of study.

2.1 Course Learning Outcomes

- Students will learn the fundamental concepts and principles of forensic science and their significance.
- Students will understand how a forensic investigation is initiated through preservation of evidences, as well as chemical, physical and biological methods of their analysis including analysis of DNA and other bodily fluids.
- Students will learn how to establish identity of an individual by document evaluation, fingerprints, footprints and DNA analysis.
- Students will obtain hands-on-experience in some of the basic biochemical processes involved in forensic investigation.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to forensic sciences **No. of hours: 10**

Basic Principles and Significance; History and Development of Forensic Science; Defining the scene of investigation; Collection, Packaging, Labelling and Forwarding of biological exhibits to forensic laboratories; Preservation of biological evidence; Importance of Health and Safety Protocols in sample collection and analysis.

UNIT II: Biological science and its application in investigation **No. of hours: 20**

Biochemical analysis of various biological evidences like blood, semen & other biological fluids, viscera, bite marks, hair (animal and human), fibers & fabrics, pollen and soil; Establishment of identity of individuals - fingerprints, footprints, blood and DNA analysis, anthropology – skeletal remains, Odontology; Time of death - rigor mortis, liver mortis, algor mortis, forensic entomology. Biochemical basis for determination of cause of death, case studies

UNIT III: Chemical science and its application in investigation No. of hours: 15

Detection of drugs of abuse and narcotics in biological samples; Toxicological examination of viscera, detection of petroleum products, food adulteration; Analysis of inks and their use in questioned document identification, blood splatter analysis, stain analysis, case studies.

UNIT IV: Recent advances in forensics No. of hours: 15

Narco analysis: theory, forensic significance, future prospect; *Brain mapping:* introduction, EEG, P-3000 wave, forensic applications, limitation of technique; *Polygraph*: Principle and technique, polygraph as forensic investigative tool, use of psychoactive drugs in forensic analysis. NHRC guidelines for polygraph test; *Facial reconstruction*: Method and technique, facial reconstruction in forensic identification; DNA Finger Printing; DNA-Introduction, source of DNA in Forensic case work, Extraction of DNA, Techniques of DNA fingerprinting-RFLP, STR, PCR. DNA fingerprinting in paternity disputes, mass disaster and other forensic case work, case studies.

PRACTICALS

CREDITS: 2 TOTAL HOURS: 60

1. TLC method for differentiation of ink/drugs
2. Fingerprint development from various surfaces
3. Handwriting identification based on class characteristic and individual characteristics
4. Microscopic examination of hair/fiber/pollen/diatom
5. Examination of blood samples: Blood grouping, DNA finger printing, Blood splatter analysis.
6. Examination of urine samples: Identification of drugs.
7. Field trip to a forensic laboratory.

2.3 References

1. James, S. H., Nordby, J. J. & Bell, S. (2014). *Forensic Science: An Introduction to Scientific and Investigative Techniques, Fourth Edition*: Taylor & Francis. ISBN 9781439853832
2. Jones, P., & Williams, R. E. (2009). *Crime Scene Processing and Laboratory Workbook First Edition*: CRC Press. ISBN 9780429249976
3. Lee, H., Palmbach, T. & Miller, M. (2001). *Henry Lee's crime scene handbook, First Edition*: Academic Press ISBN 9780080507989
4. Parikh, C. K. (2016). *Parikh's textbook of medical jurisprudence, forensic medicine and toxicology : for classrooms and courtrooms*, *Seventh Edition*: CBS Publishers and Distributors. ISBN 9788123926469
5. Saferstein, R. (2018). *Criminalistics: An Introduction to Forensic Science, Twelveth edition*: Pearson Education. ISBN 10:0134477596, ISBN 13: 9780134477596
6. Tewari, R. K., Sastry P. K., Ravikumar, K. V. (2002). *Computer Crime and Computer Forensic*, *First Edition*: Selective & Scientific Books
7. Veeraraghavan, V. (2009). *Handbook of Forensic Psychology*, *First Edition*: Selective & Scientific Books

3. **Teaching Learning Process and Assessment Methods**

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Comprehend the developments in the field of forensic sciences, learn to observe a crime scene for identification of relevant evidences and samples for forensic analysis. Understand the importance of collection, packaging and preservation of samples to ensure reliability of data generated.	Teaching will be conducted both through black board mode and power point presentation mode. Discussions and quizzes will be conducted to keep the students up-to-date with the information they have received and to gauge their conceptual understanding. Use models of crime scenes for practical training on sample identification and collection.	Internal assessment tests. Students will be given questions that are application based and require analytical skills
II.	Understand the importance of precision, reproducibility and accuracy in identification of a biological sample. Learn the methods to identify the accurate age, sex and identity of an individual and identify time and cause of death in a forensic investigation.	Class teaching with black board and power point presentation modes. Discussions on case studies and quizzes will be conducted to keep the students up-to-date with the information they have received and to gauge their conceptual understanding. Practical training on microscopic identification of various biological samples, finger print development from surfaces and identification of fingerprints.	Conduct of Internal assessment tests. PowerPoint presentation on the assigned topics.
III.	Gain knowledge about the methods used to analyse samples for drug testing, ink and stain testing and document and handwriting verification.	Power point presentation will be used to teach various methods. Use of blackboard and general discussions in the class. Practical analysis of urine samples for drug tests. Practical analysis of inks and stains.	Internal assessment tests will be conducted. Analyzing case studies. Open book tests to promote self-learning.
IV	Understand the physiology and biochemistry behind tests like Narcoanalysis, polygraphy, lie detection and facial reconstruction. Also, learn the	Teaching using chalk and board and video tutorials. Expert lecture on course related topics and filed trip	Internal assessment tests will be conducted. A PowerPoint presentation on

	importance of DNA fingerprinting in forensic investigations	to labs. Practical exercises on DNA fingerprinting.	any interesting case study and the use of forensic technology in investigation. Practical record book assessment, oral discussion and question- answer sessions on practical topics.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Forensic biology; blood splatter analysis; toxicology; narco-analysis; DNA fingerprinting; polygraph; odontology; forensic entomology.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Recombinant DNA Technology (BCH GE-7)
Semester - IV

1. Course Objectives:

The objective of the course is to teach basics of theory and practical aspects of recombinant DNA technology and the various techniques for DNA manipulation in prokaryotes and eukaryotes. The course will also outline the applications of this knowledge for the development of diagnostics, therapeutics and vaccines.

2.1 Course Learning Outcomes:

The students after completing this course will be able to understand:

- Principles and importance of gene cloning
- Various methods for screening of recombinants and identification of cloned gene
- Polymerase chain reaction and DNA sequencing
- Recombinant gene expression system
- Application of recombinant technology in the production of Biopharmaceutical processes and products such as insulin, vaccines and DNA finger printing.

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to recombinant DNA technology **No. of hours: 8**

Overview of gene cloning. Restriction, modification systems and DNA modifying enzymes, DNA analysis by electrophoresis.

UNIT II: Cloning vectors for prokaryotes and eukaryotes **No. of hours: 12**

Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors for *E. coli* like pBR322, pUC8, pGEM3Z. Cloning vectors based on M13 and λ bacteriophage. Ti plasmid, BAC and YAC.

UNIT III: Introduction of DNA into cells and selection of recombinants No. of hours: 12

Ligation of DNA molecules. Introduction of DNA into cells, Transformation, selection for transformed cells. Identification of recombinants, blue-white selection. Identification of recombinant phages. cDNA and Genomic libraries.

UNIT IV: Polymerase chain reaction and DNA sequencing **No. of hours: 08**

Fundamentals of polymerase chain reaction, designing primers for PCR. DNA sequencing by Sanger's method and automated DNA sequencing.

UNIT V: Expression of cloned genes **No. of hours: 12**

Vectors for expression of foreign genes in *E. coli*, cassettes and gene fusions. Production of recombinant protein by eukaryotic cells. Fusion tags and their role in purification of recombinant proteins.

UNIT VI: Applications of genetic engineering in biotechnology **No. of hours: 12**

Production of recombinant proteins such as insulin and factor VIII. Gene therapy. Genetically modified herbicide glyphosate resistant crops. Ethics concerns.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. DNA estimation by UV spectrophotometry.
2. Isolation of plasmid DNA from *E. coli.*
3. Restriction digestion and agarose gel electrophoresis.
4. Amplification of a DNA fragment by PCR.

2.3 References

1. Brown, T. A. (2016) *Gene Cloning and DNA Analysis: An Introduction,* (7th ed.). Wiley-Blackwell Publishing (Oxford, UK); ISBN: 978-1-119-07256-0
2. Glick, B.R., Pasternak, J.J., Patten, C. L. (2010) *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4th ed.). ASM Press (Washington DC); ISBN: 978-1-55581-498-4.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be introduced to purpose and importance of gene cloning, Restriction, modification systems and DNA modifying enzymes, DNA analysis by electrophoresis.	Teaching will be conducted through both black board mode and power point presentation mode. They are also encouraged to attend the practicals for the better understanding of the techniques.	MCQ tests, assignments, Analytical questions
II.	Students will gain insight of different vectors used for gene cloning like pBR322, pUC8, pGEM3Z,	Students will be asked to orally revise the previous class before every new class helping them in	Students will be given assignment on different topics and will be asked to deliver a power-point

	Cloning vectors based on M13 and λ bacteriophage. Plant vectors like Ti plasmid, high capacity vectors like BAC and YAC.	better understanding and their doubts cleared, if any. Regular classroom teaching, visual aids, discussions	presentation on the applications of vectors, MCQ tests and quizzes to assess regular understanding of the topic
III.	Students will learn in detail about Ligation of DNA molecules into vectors, Introduction of recombinant DNA into host cells, Transformation, selection for transformed cells. Identification of recombinants through blue-white selection. Identification of recombinant phages. Gene libraries.	Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted through both black board mode and power point presentation mode.	Mid-term tests will be conducted.
IV	Students will gain insight of principle of polymerase chain reaction, designing primers for PCR.DNA sequencing by Sanger's method and automated DNA sequencing.	Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted through both black board mode and power point presentation mode.	Assignments and presentations , analytical problems and class tests
V.	Students will learn about the Vectors used for expression of foreign genes in *E. coli*, cassettes and gene fusions. Production of recombinant protein by eukaryotic cells. Fusion tags and their role in purification of recombinant proteins	Presentations, Classroom Teaching, connect with practicals, discussions	Presentations and assignments
VI.	Students will gain knowledge about the various application of recombinant DNA technology through various examples like Production of recombinant proteins such as insulin and factor VIII. Gene therapy. Genetically	Visual aids, Presentations, Classroom Teaching and discussions.	Internal assessment test (end term) will be conducted.

	modified herbicide glyphosate resistant crops. Ethics concerns.		

(**Assessment tasks enlisted here are indicative in nature)

4. Key Words

Genetic Engineering, Recombinant Proteins, Biotechnology

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES
Biochemical Techniques (BCH SEC-1)
Semester - III

1. Course Objectives

The objective of the course is to introduce to the students, various techniques that are used in a biochemistry lab and to provide them with an understanding of the principle underlying these techniques and laboratory skills in the form of practical exercises so that students can apply this knowledge to pursue research.

2.1 Course Learning Outcomes

The course is designed for undergraduate students to learn the basic concepts of various techniques used in Biochemistry. The course will enable students to:

- Acquire knowledge about the principles and applications of spectrophotometric and chromatography techniques used in a biochemistry lab.
- Learn about the principle and applications of electrophoresis and centrifugation techniques.
- Obtain hands-on-experience and laboratory skills expected of any biochemist working in a research lab.

THEORY

CREDITS: 2 **TOTAL HOURS: 30**

UNIT I: Spectroscopic Techniques **No. of hours: 6**

Electromagnetic radiation, interaction of radiation with biomolecules, principle of UV-visible absorption spectrophotometry, Lambert's Law, Beer's Law, Working of a spectrophotometer. Applications of UV-visible absorption spectrophotometry in Biochemistry. Fluorescence spectrophotometry and its applications in biochemistry.

UNIT II: Chromatography **No. of hours: 10**

Introduction to chromatography. Principle and applications of Paper Chromatography, Thin Layer Chromatography, Ion-Exchange Chromatography, Gel filtration and Affinity Chromatography.

UNIT III: Electrophoresis **No. of hours: 8**

Principle of electrophoresis, Polyacrylamide gel electrophoresis (native and denaturing) for proteins and nucleic acids. Agarose gel electrophoresis, Isoelectric focusing of proteins, two-dimensional. Detection and identification of proteins and nucleic acids and determination of molecular weight.

UNIT IV: Centrifugation **No. of hours: 6**

Principle of centrifugation, basic rules of sedimentation, sedimentation coefficient. Various types of centrifuges, types of rotors. Application of centrifugation, differential centrifugation, density gradient centrifugation (zonal and isopycnic).

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Determination of absorption maxima (λ_{max}) of small molecules and macromolecules.
2. Verification of Beer's Law.
3. Determination of molar extinction coefficient.
4. Separation of amino acid acids/sugars by thin layer chromatography (TLC)
5. Separation of proteins by gel filtration chromatography
6. Separation of proteins by ion-exchange chromatography
7. Separation of nucleic acids using agarose gel electrophoresis
8. Separation of protein by SDS-PAGE.

2.3 References

1. Boyer, R. F. (2012) *Biochemistry Laboratory: Modern Theory and Techniques*, (6th ed.), Boston, Mass: Prentice Hall; ISBN-13: 978-0136043027.
2. Plummer, D. T. (1998) *An Introduction to Practical Biochemistry* (3rd ed.), Tata McGraw Hill Education Pvt. Ltd. (New Delhi); ISBN: 13: 978-0-07-099487-4 / ISBN:10: 0-07-099487-0.
3. Wilson, K. & Walker J (2010) *Principles and Techniques of Biochemistry and Molecular Biology*, (7th ed.), Cambridge University Press; ISBN 978-0-521-51635-8.

Additional Reading

1. Cooper, T. G. (2011) *The Tools of Biochemistry* (2nd ed.), Wiley-Interscience Publication (New Delhi); ISBN: 13:9788126530168.
2. Freifelder, D. (1982) *Physical Biochemistry: Applications to Biochemistry and Molecular Biology*, (2nd ed.), W.H. Freeman and Company (New York); ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will learn about the principle and applications of spectrophotometry and flourimetry.	Teaching using chalk and board; Oral discussion sessions in the class. Powerpoint presentations.	Problems will be assigned related to Beer's Law and Lambert's Law to test the understanding of students.

II	Students will learn the principle of various chromatographic techniques like gel filteration, Ion exchange.	Teaching using chalk and board; Oral discussion sessions in the class. Powerpoint presentations.	Practical exercises are designed whereby the students get hands on experience with these chromatography techniques.
III	Students will learn about electrophoretic techniques, their principle and applications in analyzing proteins and nucleic acids	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class	Various analytical problems will be assigned to students related to electrophoretic separation.
IV	Students will learn about the basic rules of sedimentation, various types of centrifuges and rotors.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class	Demonstration with the help of centrifuges and rotors to improve their understanding.

4. Keywords

Spectrophotometry, Chromatography, Proteins, Nucleic Acids, Centrifugation and Electrophoresis

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES
Biostatistics (BCH SEC-2)
Semester - III

1. Course Objectives

The primary objective of this course is to provide understanding about the principles of biological data collection, statistical analysis and presentation. The course will also provide hands-on-experience through practicals that are well correlated with the theory topics and are designed to support skill oriented learning outcomes in the management of biological data.

2.1 Course Learning Outcomes

Learners will be able to:

- Understand the principles of biological data collection, statistical analysis and presentation.
- Appreciate various factors that influence the type of sample collected and sample size.
- Analyze and interpret biological data using appropriate statistical tools
- Apply the principles of biological data management in real life situations
- Improvise their computational, mathematical and computer skills, which would increase their eligibility to pursue research based higher education.

THEORY

CREDITS: 2 **TOTAL HOURS: 30**

UNIT I: Data Collection and Presentation **No. of hours: 4**

Importance of statistical analysis in biological data management. Sampling schemes – Simple Random sampling, Systemic sampling, Stratified sampling, Cluster sampling, Non probability sampling; Types of numerical data – nominal data, ordinal data, ranked data, discrete data, continuous data; Modes of presenting data: Frequency distributions, Relative frequency.

UNIT II: Measures of central tendency and analysis of variance **No. of hours: 12**

Mean, median, mode; Co-efficient of variation and standard deviation; Range and interquartile range; Grouped mean and grouped variance; Frequency distributions; One way ANOVA; Two-way ANOVA; AMOVA; student's t test

UNIT III: Probability **No. of hours: 4**

Operations on events, Venn diagrams, Conditional Probability; Probability distributions.

UNIT IV: Hypothesis Testing **No. of hours: 4**

General concepts – Null hypothesis, alternative hypothesis, Rejection of hypothesis; Type I and Type II errors; P value and sample size estimation.

UNIT V: Regression and Correlation **No. of hours: 6**

Chi Square Test – Observed and expected frequencies, Calculating p values, assumptions of a chi square goodness of fit; Correlation –Two-way scatter plot, Pearson's correlation coefficient; Regression – regression concepts, simple linear regression; Calculation of R^2 and ρ.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Collection of data - Random sampling method; Stratified sampling method; Cluster sampling method
2. Data representation - Frequency and relative frequency distribution table, Plotting different biological data in a best representative graphical format.
3. Data analysis - Calculating Mean, median, mode, variance, standard deviation and standard error for a given data set. Standard t-test for grouped samples. Analysis of 2 way variance
4. Chi square goodness of fit test. Regression analysis and calculating regression coefficient
5. Learning to analyze data using SPSS or R software
6. Project assignment.

2.3 References

1. Michael, C.W. (2015) *The Analysis of Biological Data* (2nd ed.), Macmillan Publishers, ISBN-10: 1-936221-48-9; ISBN-13: 978-1-936221-48-6
2. Pagano, M . and Gauvreau , K .(2018) *Principles of Biostatistics* (2nd ed.), Chapman and Hall/CRC; ISBN 9781138593145

Additional Resources:

1. Zar, J.H. (2010) *Biostatistical analysis*, (5th ed.), Pearsons Int. Edition; ISBN- 978-0-13-206502-3.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Understand the principles of biological data collection and presentation. Learn and appreciate various factors that	Teaching will be conducted both through black board mode and power point presentation mode. Exercises on	Internal assessment tests. Students will be given questions that are application based and

	influence type of sample collected and sample size.	Collection and presentation of data. Field exercises on collection of data	require analytical skills
II.	Analyze and interpret biological data using simple statistical tools like mean, median, mode, variance and standard deviation. Apply the principles of biological data management in real life situations Improve their computational, mathematical and computer skills by learning to use ANOVA,AMOVA and student t-test on free access statistical software	Teaching will be conducted both through black board mode and power point presentation mode. Exercises on statistical analysis of biological data. Learning to analyze data using SPSS or R software	Conduct of Internal assessment tests Students will be given questions that are application based and require analytical and computational skills
III.	Understand the concept of probability and the importance and use of probability in analyzing biological data.	Teaching will be conducted both through black board mode and power point presentation mode.	Students will be given MCQ based tests and quiz
IV	Learn and appreciate various factors that influence stating and formulating a hypothesis, relevance to type of sample collected and sample size.	Teaching will be conducted both through black board mode and power point presentation mode. Analyzing case studies to understand hypothesis formulation	Formulate a hypothesis on any are/topic of interest, determine appropriate sample size and collect data.
V	Understanding how to manage data for a goodness of fit chi-square test versus an interdependence chi-square test. Learn and appreciate various factors that influence the use of correlation and regression analysis for biological data.	Teaching will be conducted both through black board mode and power point presentation mode. Exercises on statistical analysis of biological data. Learning to analyze data using SPSS or R software	Internal assessment tests will be conducted. Analyze data collected using appropriate statistical tools and present the data.

4. Keywords

Statistical analysis, biological data collection, sampling, data presentation, measures of central tendency, ANOVA, chi-square, regression

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES
Research Methodology (BCH SEC-3)
Semester – III / IV

1. Course Objectives

The main objective of this paper is to provide students with a general introduction to the methodological foundations and tools used in research for an understanding of the ways to identify problems, develop hypotheses and research questions and design research projects. The course will expose students to the range of designs used in research in laboratory, field experiments, surveys and content analysis. It will also provide an introduction to the concept of controls, statistical tools and computer applications used in research. In addition, the course will impart knowledge of scientific writing, oral presentation and the various associated ethical issues.

2. 1 Course Learning Outcomes:

By studying this paper students will be able to:

- Define research, learn the importance of research and its link with theoretical knowledge
- Describe the research process and the principle activities, skills and ethics associated with the research process
- Describe and compare the major quantitative and qualitative research methods
- Construct an effective research proposal
- Understand the importance of research ethics use the computer software for organization and analysis of data.
- Develop skills in the art of scientific writing and oral presentation

2.2 Course Contents

THEORY

CREDITS: 2 **TOTAL HOURS: 30**

UNIT I: Objectives of research **No. of hours: 4**

Definition, objectives, types of research, classification, various phases of research.

UNIT II: Research proposals and literature survey **No. of hours: 6**

Research proposal and aspects, Review of literature using appropriate sources – reviews, patents, research papers, books.

UNIT III: Basic principles of research design **No. of hours: 6**

Types of research designs – exploratory, descriptive, experimental, survey and case study.

UNIT IV: Experimental, sampling design and data collection **No. of hours: 6**

Sample - types, criteria, characteristics and steps; Tools and techniques to execute experiments; Observation, questionnaire, interview

UNIT V: Interpretation, report writing and the art of oral presentation
No. of hours: 4

Report writing, format of publications in research journals, how to present papers and research findings

UNIT VI: Bioethics and Plagiarism in Research **No. of hours: 4**

Biosafety and Ethics - compliance and concerns; Plagiarism; Introduction to Intellectual Property Rights; Citation and acknowledgement

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Writing of a mini-review paper
2. Design of a research survey on a specific problem
3. Idea presentations in small groups
4. Interaction with an expert during special lecture

2.3 References

1. Cresswell, J. (2009) *Research Design : Qualitative and quantitative Approaches* Thousand Oaks CA, (3rd ed.), Sage Publications
2. Kothari, C.R. (2004) *Research Methodology: Methods and Techniques* (2nd ed.), New Age International Publishers.
3. Kumar, R. (2011) *Research Methodology: A Step-by-Step Guide for Beginners* (5th ed.), SAGE publisher
4. Walliman, N. (2017) *Research Methods: The Basics*, (2nd ed.), London ; New York : Routledge
5. WHO (2001) *Health Research Methodology – A Guide for Training in Research Methods.*

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be able to define research and understand its objectives. They will recognize the various types and classes of research.	Teaching will be conducted through both black board mode and power point presentation mode.	Internal assessment tests will be conducted. Group discussions will be assigned.

II.	Students will gain insight about the importance of Research proposals and literature survey. They will be made capable in identifying broad area of research and write research proposal. They will be able to review literature using a wide variety of sources like web and libraries	Group discussions; Idea presentations; Proposing a research topic; Perform a literature survey on the given/proposed topic	Assign group discussion on specific topics; Will be asked to retrieve literature based on a given topic. Students will be encouraged to meet departmental faculties and discuss on their successful research proposals.
III.	Students will learn the basic principles of research design and its various types.	Group discussions; Design of a proposed research topic; Online courses on the topic	Internal assessment tests will be conducted. Report/paper writing will be assigned
IV	Students will gain insight about the experimental, sampling design and data collection. They will learn a variety of ways to collect the samples. They will be able to devise optional plans, tools and techniques for experimental design and its execution	Plan the sampling and data collection method of their proposed topic of research. Learn the proper way of data reporting and its record keeping	Internal assessment tests will be conducted. Group discussions; Paper presentation; Seminars
V.	Students will gain knowledge about data interpretation, report writing and the art of oral presentation. They will not only be able to understand the format of report writing but also scientific publications	Learn the skill of report and publication writing in their proposed topic of research based on input from teachers	Will be assigned writing of small reports and defending them orally. They will be encouraged to present scientific papers as well.
VI.	Students will learn about the role of bioethics and plagiarism in Research. They will be educated to follow ethics compliance and concerns. They will be educated about the concept of Citation and acknowledgement	Articles on these issues will be provided to students. Classical mode of chalk and board teaching as well as power point presentations will be used. Experts in these areas will be invited to deliver special lectures.	Students will be assigned the task of retrieving bioethics, plagiarism, ethical issues related policies of the government or of institutions. They will be assigned the task of identifying citations of publications of faculties.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Research methodology; Patents; Plagiarism; Ethics; Biosafety; Report writing

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES
Bioinformatics (BCH SEC-4)
Semester - IV

1. Course Objectives

The objective of this course is to impart basic understanding of bioinformatics and computational biology. The course will introduce the broad scope of bioinformatics by discussions on the theory and practices of computational methods in biology. This course also aims to provide students with a practical hands-on experience with common bioinformatics tools and databases. Students will be trained in the basic theory and application of programs used for database searching, protein and DNA sequence analysis, and prediction of protein structures.

2.1 Course Learning Outcomes

After completion of the course, a student will:

- Understand the basics of bioinformatics and computational biology and develop awareness of the interdisciplinary nature of this field.
- Gain the ability to use several softwares/tools in biology
- Gain confidence to discuss, access and use biological databases in public domain
- Understand protein structure using visualization softwares
- Be able to gain understanding of sequence alignments
- Be able to analyze phylogeny using alignment tools
- Comprehend the fundamental aspects of *in-silico* protein structure prediction
- Understand how theoretical approaches can be used to analyze biological systems
- Obtain knowledge on applications of bioinformatics from genomes to personalized medicine.

2.2 Course Contents

THEORY

CREDITS: 2 **TOTAL HOURS: 30**

UNIT I: Introduction to bioinformatics **No. of hours: 4**

Introduction to Bioinformatics, Computer fundamentals – Operating Systems, Hardware, Software, Programming languages in bioinformatics - PERL/R programming, role of supercomputers in biology, Historical background. Scope of bioinformatics - Genomics, Proteomics, Computer aided drug discovery and design (CADD) and Systems Biology.

UNIT II: Biological databases and data retrieval **No. of hours: 8**

Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Organism specific databases (E. coli, yeast, *Arabidopsis*, mouse, *Drosophila melanogaster*), Structure viewers (Ras Mol, J mol) and File formats.

UNIT III: Sequence alignment & phylogeny **No. of hours: 8**

Similarity, identity and homology. Concept of Alignment – local and global alignment, pairwise and multiple sequence alignments, amino acid substitution matrices (PAM and BLOSUM), BLAST and CLUSTALW, Definition of phylogeny and its importance, Methods of Phylogenetic tree generation, Phylip

UNIT IV: Genomics **No. of hours: 4**

Introduction to genomics, comparative and functional genomics, gene structure in prokaryotes and eukaryotes, Genome annotation, gene prediction approaches and tools.

UNIT V: Protein sequence, structure prediction and analysis **No. of hours: 6**

Protein Structure - Primary, Secondary and Tertiary structure, Protein structure prediction methods: Homology modeling, Fold recognition and *ab-initio* methods, Ramachandran plot.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Sequence retrieval (protein and gene) from NCBI and Molecular file formats - FASTA, GenBank/Genpept.
2. Structure download (protein and DNA) from PDB and Molecular viewer by visualization software (Pymol / Rasmol/Jmol)
3. BLAST suite of tools for pairwise alignment
4. Multiple sequence alignment (CLUSTALW/TCoffee) and construction of guide trees
5. Gene prediction using GENSCAN/GLIMMER
6. Primary sequence analyses (Protparam) and Secondary structure prediction (GOR, nnPredict).
7. Tertiary structure prediction (SWISSMODEL) and Protein structure evaluation - Ramachandran map (PROCHECK

2.3 References

1. Chandra, S.M., Choudhary, K.R. and Mir Asif Iquebal A.M. (2017) *Basic Applied Bioinformatics* John Wiley & Sons; ISBN9781119244370
2. Ghosh, Z. and Mallick, B., (2008) *Bioinformatics – Principles and Applications*, (1st ed.) Oxford University Press (India), ISBN: 9780195692303.
3. Gromiha, M.M. (2010). *Protein Bioinformatics: From Sequence to Function*; Academic Press eBook; ISBN: 9780123884244 Paperback ISBN: 9788131222973

4. David M. (2004). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press; ISBN 978-087969712-9
5. Andreas D., Baxevanis D.A. and Ouellette Francis B.F. (2005), Bioinformatics: A *Practical Guide to the Analysis of Genes and Proteins* (3rd ed.), John Wiley & Sons, Inc. (New Jersey), ISBN: 0-47147878-4.

Additional Reading

1. Krane, D.E. and Raymer, M. L. (2006). *Fundamental concepts of bioinformatics*, Pearson Education Inc.; ISBN 10: 0805346333 ISBN 13: 9780805346336
2. Pevsner, J. (2003). *Bioinformatics and Functional Genomics* (1st ed.), John Wiley & Sons, Inc. (New Jersey); ISBN: 0-47121004-8.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be familiarized with the concept of Bioinformatics & Computational tools with applications in biology	Outlining history of development about Bioinformatics through power point presentations and chalk & board method;	Discussion of research and review articles and class presentations
II.	Students will learn about Biological Databases and the types of databases. They will also understand various file formats used for sequence and structure analysis	Traditional chalk & board method with powerpoint presentations on biological databases	Computer assisted quizzes, assignments. Students will be assigned a topic and asked to search for databases associated to the topic
III.	Students will learn about sequence alignment methods. Pairwise and multiple sequence alignment will be discussed in detail with examples of BLAST and CLUSTALw. They will also learn methods for phylogeny	Chalk and board and notes; Power point presentations for images for clarity of concepts; Research papers will be discussed	Class presentations and assignments will help students understand phylogeny
IV	Students will understand different	Power point presentations; Chalk and board; Student	Assignments & Quiz

	applications of genomics in gene prediction. Functional Genomics & Comparative Genomics will be discussed	interaction in class	
V.	Students will learn the various approaches for protein tertiary structure prediction, tools used and validation methods employed.	Chalk & board method and Powerpoint presentations. Group discussions will be held.	Assignments and Class presentations with hands on computer training. Students will be assigned the task of identifying tools used in structure based drug discovery from research papers.

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Biological Databases, NCBI, PDB, Visualization Softwares, Sequence Alignment, BLAST, Gene Prediction, Secondary Structure Prediction, Protein Structure Prediction.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES
Microbial Techniques (BCH SEC-5)
Semester - IV

1. Course Objectives

This course aims to impart basic understanding of microbial techniques by hands-on-experience on working with microorganisms. It will also provide knowledge about various control methods for the growth of microbes and the characteristic features of different microbes

2.1 Course Learning Outcomes

After completion of this course, a student will be able:

- To visualize and identify various microorganisms
- To culture microorganisms in aseptic conditions
- To prepare and sterilize different types of media
- To maintain different types of cultures
- To carry out research using microorganisms.
- To learn the principles behind and importance of sterilization while working in varied areas of biology in various laboratories.

2.2 Course Contents

THEORY

CREDITS: 2 **TOTAL HOURS: 30**

UNIT I: Introduction **No. of hours: 4**

Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister and Alexander Fleming. Development of various microbiological techniques and golden era of microbiology.

UNIT II: Microbial nutrition and growth **No. of hours: 8**

The common nutrient requirements. Nutritional types of microorganisms. Culture media and its components, Synthetic or defined media, Complex media, Enriched media, Selective media, Differential media. Isolation of Pure culture: Streaking, Serial dilution and Plating methods, cultivation, maintenance of pure cultures. Microbial Growth: phases of growth, measurement of microbial growth

UNIT III: Control of microorganisms by physical and chemical methods
No. of hours: 6

Mechanism of Dry Heat, Moist Heat, Hot air oven, Filtration and Radiations, Use of Phenolics, alcoholics, halogens, heavy metals, aldehydes and gases for sterilization.

UNIT IV: Bacterial, Fungal and Algal cell organization and staining
No. of hours: 8

Overview of characteristic features of bacterial, fungal and algal cell. Composition and detailed structure of gram- positive and gram- negative cell wall. Simple staining and negative staining of bacteria. Mechanism of gram staining.

UNIT V: Introduction to Viruses **No. of hours: 4**

General characteristic features of viruses. Nacked and envelop viruses. Examples of RNA and DNA viruses. Subviral particles: viroids, prions, virusoids and their importance. Isolation and cultivation of viruses. Virus purification and assays

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Microbiology Laboratory: Basic rules and requirements.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory.
3. Preparation of glassware for microbiological work, cotton plugs, medium and their sterilization.
4. Sterilization of heat sensitive material by filtration.
5. Demonstration of presence of microflora in the environment by exposing nutrient agar plates to air.
6. Study of different shapes of bacteria, fungi and algae using permanent slides/pictographs
7. To stain bacteria using crystal violet/methylene blue.
8. To perform Gram's staining.
9. To prepare temporary mount of algae.
10. To prepare temporary mount of fungi.
11. Isolation of pure cultures of bacteria by streaking method.
12. Enumeration of colony forming units (CFU) count by spread plate method/pour plate
13. Study the morphological structures of viruses (DNA and RNA) and their important characters using electron micrographs.
14. Isolation and enumeration of bacteriophages (PFU) from water sample.

2.3 References

1. Willey, J.M, Sherwood, L.M. and Woolverton, C.J. (2017). *Prescott's Microbiology*, (10^{th} ed.), McGraw Hill Higher Education; ISBN13: 9781259657573.
2. Pelczar, Jr M.J., Chan, E.C.S and Krieg, N.R. (2004). *Microbiology*, (5^{th} ed.), Tata McGraw Hill; ISBN13: 9780074623206.

3. Cappucino, J. and Sherman, N. (2013). *Microbiology: A Laboratory Manual*. (10th ed.) Pearson Education Limited; ISBN13: 9780321840226

Additional Resources:

1. Madigan, M.T., Martinko, J.M., Dunlap, P.V. and Clark, D.P. (2010). *Brock Biology of Micro-organisms*. (13th ed.) Pearson Education, Inc. ISBN 13: 9780321649638.
2. Dubey, R.C. and Maheshwari, D.K. (2010). *Practical Microbiology*. (1st ed.). S. Chand. ISBN: 81-219-2153-8.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will gain overall knowledge and understand the significance of microbiology as a discipline	Chalk and board teaching method, regular question-answer activities. Consultation of text books and reviews	Internal assessment tests (mid- term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics.
II.	Students will gain insight into nutrient requirements of microbes, microbial growth and different types of cultures and media used for the growth of microbes.	Students will be asked to orally revise the previous class before every new class helping them in better understanding of the particular topic. Teaching will be conducted both through black board mode and powerpoint presentation mode.	Assessment through class test at the end of the module. Questions will be given as a part of the assignment. Students will also be assessed on the basis of their performance and involvement during practical classes.
III.	Students will learn about the control of microorganisms by various physical and chemical methods.	Students will be asked to orally revise the previous class before every new class helping them in better understanding of the particular topic. Teaching will be conducted both through black board mode and powerpoint presentation mode.	Assessment through interactive discussion in the class and periodic question-answer sessions during teaching.
IV	Students will learn about the bacterial, fungal and algal cell organization and staining.	Students will be asked to orally revise the previous class before every new class helping them in better understanding of the particular topic. Teaching will be conducted both through black board mode and powerpoint presentation mode.	Assessment through class test at the end of the module. Questions will be given as a part of the assignment.

V.	Students will learn about general characteristics of viruses and subviral particles like viriods, prions and virusoids.	Students will be asked to orally revise the previous class before every new class helping them in better understanding of the particular topic. Teaching will be conducted both through black board mode and powerpoint presentation mode.	Students will be evaluated through class discussion and their performance and involvement during practical classes

(**Assessment tasks enlisted here are indicative in nature)

4. Keywords

Microorganisms, microbial growth, staining, culture, media

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I.	Programme Coordinator and Head (Dean, Faculty of Interdisciplinary and Applied Sciences)	:	Professor Suman Kundu Department of Biochemistry UDSC, New Delhi

II. Course Coordinators and Faculty members

Department of Biochemistry UDSC, New Delhi	:	Professor Vijay K. Chaudhary Professor Debi P. Sarkar Professor Alo Nag Dr. Amita Gupta Dr. Garima Khare

III. Working Committee Members (teachers) from Department of Biochemistry of the following colleges – Daulat Ram College, Deshbandhu College, Institute of Home Economics, Shivaji College, Shaheed Rajguru College of Applied Sciences for Women, Sri Venkateswara College, Bhaskaracharya College of Applied Sciences -

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IV. Working Committee Student Members from Department of Biochemistry –

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