BANARAS HINDU UNIVERSITY

M.Sc. / M.Sc. (Tech.) / M.C.A. Courses

Offered by

FACULTY OF SCIENCE

CONTENTS

Faculty of Science

Ordinances governing M. Sc., M. Sc. (Tech.) and M.C.A. Degree Programmes

(Effective from 2009-10)

Under the powers conferred by Section 4A of the Banaras Hindu University Act 1915, as amended, and under the provision of Section 18 of this Act, the University hereby institutes the four semester programme for the degree of Master of Science, M.Sc. in Physics, Chemistry, Zoology, Botany, Computer Science, Geography, Mathematics, Statistics, Psychology, Home Science, Biochemistry, Molecular & Human Genetics, Petroleum Geosciences, Bioinformatics, Applied Microbiology, Environmental Science, Biotechnology and Six semester programme for M.Sc. (Tech.) Geology, M.Sc. (Tech.) Environmental Science and Technology, M.Sc. (Tech.) Geophysics and Master of Computer Applications (M.C.A.) and makes the following ordinances governing admission, course of study, examinations and other matters relating to these Degrees under the Faculty of Science of the Banaras Hindu University.

1. ADMISSION TO THE M.Sc./ M.Sc. (Tech.)/ M.C.A. PROGRAMMES

(i) **(a)** Admission to all the M.Sc., M.Sc. (Tech.) and MCA programmes, except for those described below, in the Faculty of Science shall be made on merit in the PET (Post-graduate Entrance Test).

(b) Admission to M.Sc. Biotechnology shall be made on merit through an All India Combined Entrance Examination.

(ii) **(a)** Each Post-graduate Department of the Faculty of Science shall have an Admission Committee constituted under Statute (xviii) of the Academic Council consisting of the Head of the Department and two senior members of the teaching staff of the department in station.

(b) For PG programmes of Applied Microbiology, Environmental Science, and Petroleum Geosciences, the admission committee shall consist of Head of the Department with which the programme is associated, two senior members of the teaching staff of the department in station, coordinator of the programme and one senior teacher participating in the programme.

(c) For Bioinformatics, and Environmental Science and Technology programmes, the admission committee shall consist of the coordinator and two senior teachers participating in the programme.

(iii) For PG Programmes, admission cannot be claimed by any candidate as a matter of right. The admission or re-admission of a candidate shall be entirely at the discretion of the Admission Committee, which may refuse or admit any student without assigning any reason therefor.

(iv) On his/her selection for admission to M.Sc./M.Sc.(Tech.)/M.C.A. Programme, the candidate shall, within the time fixed by the Dean, deposit the tuition and other fees prescribed for the programme. If the candidate fails to deposit the fees within the stipulated time, his/her selection shall automatically stand cancelled. Such a candidate shall not be admitted to the concerned programme unless a fresh order of selection or extension of date for payment of fees is issued by the Principal/Dean of the Faculty concerned.

(v) There is no provision for re-admission in the 1st semester of M.Sc./M.Sc. (Tech.)/M.C.A. Programmes (except as stated in promotion rules).

(vi) **Foreign Students-** Applications of foreign nationals nominated by the Government of India under scholarship schemes and self-financing Foreign Nationals shall be entertained for the aforesaid programmes. They shall not be subject to the Entrance Test provided they have passed the equivalent qualifying examinations and satisfy the minimum eligibility requirements.

Reservation to the extent of 15% of the number of seats in a programme, on supernumerary basis, for Foreign Nationals shall be made for admission to each of the various aforementioned programmes in the Faculty/MMV provided the applications are routed through the office of International Students Advisor, BHU. The International Students Advisor shall get examined the eligibility etc. of each applicant and will issue the eligibility letter to the concerned foreign national, if found eligible. Further, details of the process etc. shall be available from the office of the International Students Advisor, BHU, Varanasi, India.

(V) Reservation and Weightages

1. 15% Seats shall be reserved for Scheduled Caste and 7.5% for Scheduled Tribe candidates in each subject. Admission against these seats shall be made provided the candidate has passed the qualifying examination and appeared in the Entrance Test. The vacant seats reserved for SC/ST candidates, if any, shall be filled as per Government of India Rules. **Appearance in the Postgraduate Entrance Test is mandatory for admission**.

2. 5% supernumerary seats shall be reserved for the sons/ daughters of permanent employees (including those on probation) of the University currently in service or were in service during the academic session immediately preceding the one (session) for which the Entrance Test is held, provided the candidate fulfils the minimum eligibility requirements and qualifies in the PET. BHU employees' sons/daughter's category applicants shall be required to submit the certificate of the employee ward only in the prescribed format duly signed and issued by the Dy. Registrar (Administration) if called for admission. However, this facility is not available in MCA programme.

3. 3% seats shall be reserved for PC (Physically Challenged) candidates (visually impaired 1% + hearing impaired 1% + orthopaedically handicapped 1%) provided they fulfill the minimum eligibility requirements and qualify in the PET. They shall have to submit a PC certificate issued by the district CMO at the time of submitting the application. Candidates who claim for PC category shall be considered under this category on an approval from the University Medical Board only at the time of admission.

2. M.Sc. /M.Sc. (Tech.)/ M.C.A. DEGREE PROGRAMMES

(i) The study programmes leading to Master of Science/Master of Science (Tech.) and Master of Computer Applications degrees of the University shall be conducted by the constituent Departments/Schools of the Faculty and shall be of the duration of 4 semesters for M.Sc. and 6 semesters for M.Sc.(Tech.) and M.C.A.. M.Sc. in Bioinformatics will be run at MMV.

(ii) A student of the M.Sc./M.Sc. (Tech.)/ M.C.A. degree programme shall not be permitted to seek admission concurrently to any other fulltime degree or diploma programme in the University or else where unless otherwise provided for in the Ordinances hereinafter defined.

(iii) To qualify for the M.Sc. /M.Sc. (Tech.)/ M.C.A. degree, the candidate must:

(a) satisfy the minimum requirement for entrance test as prescribed hereinafter for the M.Sc./M.Sc. (Tech.)/ M.C.A. Degree Programmes;

(b) attend regular courses of lectures, seminars, sessionals and practicals as may be prescribed for the M.Sc./M.Sc. (Tech.)/M.C.A. Examinations in the relevant prospectus of studies;

(c) pass in the required number of courses taught during the 4 or 6 semesters, as the case may be, to accumulate the stipulated minimum number of credits prescribed for the degree. An Examination shall be held at the end of each semester in various courses taught during that semester. The overall performance in sessionals, practicals and written examinations in the prescribed number of courses shall determine the result of the candidate for the M.Sc./M.Sc. (Tech.)/ M.C.A. degree in accordance with the rules and regulations prescribed for the purpose.

(d) Sessionals shall include class tests, work done in laboratory, field, library, home- work and seminar relevant to the course, as prescribed by the various Boards of Studies.

Explanation: One odd and one even semester shall comprise one academic year, and the academic year in these ordinances shall mean the year from July to June.

(iv) **(a)** A student is required to have full, i.e., 100%, attendance and condonation upto 30% can be considered for specific cogent reasons. Out of this 30%, only 10% condonation shall be permitted without taking any application from the student. Rest 20% condonation may be given by the Dean, Faculty of Science/Principal, MMV. Further, a student shall be deemed to have minimum percentage of attendance only if, apart from above, he/she has attended at least 50% of the classes in each course also. The cogent reasons for condonation are given below:

(i) Participation in NCC/NSC/NSS Camps duly supported by certificate.

(ii) Participation in University or College Team Games or Inter-State or Inter-University tournaments, duly supported by certificate from the Secretary of the University Sports Board or President of the College Athletic Association concerned.

(iii) Participation in Educational Excursion, which forms a part of teaching in any subject conducted on working days duly certified by the Dean, Faculty of Science/Principal, MMV.

(iv) University Deputation for Youth Festival duly certified by the Dean, Faculty of Science/Principal, MMV.

(v) Prolonged illness duly certified by the Medical Officer or the Superintendent, S.S. Hospital, Banaras Hindu University or any other Registered Medical Practitioner, provided such certificate is submitted to the Dean, Faculty of Science/Principal, MMV in time.

(vi) **No relaxation beyond 30% shall be considered in any case.**

(b) The attendance of a newly admitted candidate shall be counted from the date of his/her admission, or date of starting of classes which ever is later while in the case of promoted candidates, attendance shall be counted from the date on which respective class begins. However, in case of promotion after declaration of results of supplementary examination (if any), the attendance will be counted from the date of admission in the respective case.

(c) There shall be an Attendance Monitoring Committee in the Faculty/MMV under the Chairmanship of the Dean/Principal.

3. ADMISSION AND ENTRANCE TEST QUALIFICATIONS

(i) The minimum eligibility conditions for admission to various' Master's Degree programmes shall be as under [+]:

(a) For M.Sc. in Physics, Chemistry, Zoology, Botany, Computer Science[@], Geography, Mathematics, Statistics, Psychology, Home Science, (2 Year : 4 Semesters programmes)
and
M.Sc. (Tech.) Geology (3 Year: 6 Semesters programme)

B.Sc. (Hons.)*/B.Sc.* under 10+2+3 pattern, securing a minimum of 50% marks in the aggregate in Science subjects (considering all the three years of B.Sc. programme). The subject in which admission is sought must be an Honours Subject at B.Sc. (Hons.) level/subject studied in all the three years at graduate level. However, for admission to M.Sc. in Botany/Zoology, a candidate must also have offered Chemistry as one of the subjects at the graduate level at least for two years. For M.Sc. in Statistics, the candidate should also have studied Mathematics as one of the subjects at graduate level at least for two years.

[+] A candidate studying in or having qualified for a Degree in a General Course of study from BHU or any other University/Institution shall be entitled to appear in the Entrance Test for, and admission to, the next higher Course/Degree in that line or to a Professional Course only. Further a candidate admitted to, or having qualified for a Degree in any Professional Course from BHU or any other University/Institution shall be entitled to appear in the Entrance Test for, and admission to, the next higher Course/Degree only in the same professional discipline. However, a candidate studying in or having qualified for B.Ed./ B.Ed. Special/ M.Ed./ M.Ed. Special is exempted from this clause. This clause will also not be applicable for M.Sc./ M.Sc. (Tech.) in Bioinformatics, Biotechnology, Environmental Science, Environmental Science and Technology and Applied Microbiology.

Furthermore, a candidate who is registered for/already awarded, doctoral Degree from BHU or any institution in India shall not be entitled to appear in any of the Entrance Tests held for any Course in the University.

[@] Candidate must have qualified in Computer Science/ must have studied the subject (Computer Science) in all the three years. Those who have qualified in other subjects such as Computer Applications, Information Technology, etc. are not eligible.

(b) M. Sc. in Biochemistry (2 Year: 4 Semesters programme)

B.Sc. (Hons.)* in Biochemistry/B.Sc.* under 10+2+3 pattern with Biochemistry as a subject in all the three years of graduation programme, securing a minimum of 50% marks in the aggregate in Science subjects (considering all the three years of B.Sc. Course).

OR

B.Sc. (Hons.)* in Chemistry/Botany/Zoology/B.Sc.* under 10+2+3 pattern with Chemistry as a subject in all the three years of B.Sc. programme securing a minimum of 50% marks in the aggregate in Science subjects (considering all the three years of B.Sc. programme). The candidate must also have studied any two of the following subjects, *viz.*, Biochemistry, Botany, Zoology, Mathematics, Physics, Geology, Physiology, Microbiology, Biotechnology and Industrial Microbiology at least for two years at the Graduate level.

(c) M.Sc. (Tech.) in Geophysics (3 Year: 6 Semesters programme)

B.Sc. (Hons.)/ B. Sc. under 10+2+3 pattern securing a minimum of 50% marks in the aggregate in Science subjects (considering all the three years of B. Sc. programme) with Physics, Maths and one more Science subject.

(d) M.Sc. in Biotechnology **(2 Year: 4 Semesters programme)**

Bachelor's degree* under 10+2+3 pattern of education in Physical, Biological, Agricultural, Veterinary and Fishery Sciences, Pharmacy, Engineering/Technology, 4-years B.S. (Physician Assistant Course); or Medicine (M.B.B.S.) or B.D.S. with at least 55% marks at the Graduate level.

(e) M.Sc. in Molecular and Human Genetics
(Special Course) **(2 Year: 4 Semesters programme)**

B.Sc. (Hons.)*/B.Sc.* (10+2+3} or B.Sc. (Ag.) or M.B.B.S. or B.Tech./ B.E. (in Biology related disciplines) or B. Pharma from recognized University/ Institute with minimum of 55% marks (or equivalent grade points) at the qualifying examinations and not less than 55% marks at 10 & at 10+2 examinations separately.

(f) M.Sc. in Environmental Science
(Special Course) **(2 Year: 4 Semesters programme)**

B.Sc. (Hons.)/ B.Sc. (10+2+3) as well as 10 & 10+2 with a minimum of 50% marks (equivalent GPA) shall be considered eligible for admission to M.Sc. Course in Environmental Science.

(g) M.Sc. in Applied Microbiology
(Special Course) **(2 Year: 4 Semesters programme)**

B.Sc. (Hons.)/ B.Sc. with 10+2+3 pattern with any two of the following subjects: Botany, Zoology, Biotechnology, Microbiology, Chemistry, Industrial Microbiology, Life Sciences and Environmental Science & Secured at least 50% marks in aggregate.

(h) M.C.A. **(3 Year: 6 Semesters programme)**

Bachelor's degree under 10+2+3 pattern in any discipline with a minimum of 50% marks in the aggregate, with Mathematics as one of the subjects at either Intermediate or +2 (10+2) or equivalent examination, or Bachelor's level (as a main or a subsidiary subject).

(i) M.Sc. in Bioinformatics (for women in MMV.) (2 Year: 4 Semesters programme)

(A) 10+2 with Science and (B) Bachelor's degree under 10+2+3 pattern in Science/ Engineering/ Technology/ Agriculture/ Medicine/ Veterinary Science/ Pharmaceutics with at least 50% marks in aggregate.

(j) M.Sc. in Petroleum Geosciences
(Special Course) **(2 Year: 4 Semesters programme)**

B.Sc. (Hons.) Geology or B.Sc. under 10+2+3 pattern with Physics and Mathematics at + 2 level; Geology must be a subject in all the three years of B.Sc. A minimum of 50% marks in aggregate at the graduate level is essential.

(k) M.Sc. (Tech.) in Environmental Science & Technology
(Special Course) **(3 Year: 6 Semesters programme)**

Passed B.Sc. (Hons.)/ B.Sc. (10+2+3) or B.Sc. (Ag.) or MBBS or BE/ B.Tech. with a minimum of 50% marks (equivalent GPA) with a minimum 50% in aggregate at 10 & 10 +2 levels.

(ii) Candidates selected for admission to the concerned PG programme of study shall submit the following certificates:

(a) Migration certificate from the University/ Institute last attended indicating that he/she has passed qualifying examination from another University;

(b) Certificate of character from the Principal of the College last attended.

* Or an equivalent examination recognized by the Banaras Hindu University

(iii) If the Head of the Department concerned is satisfied that there are genuine difficulties in the production of the above certificates he/she shall, at the request of the candidate, give him/her time to submit the above certificates within the prescribed period. In case he/she is unable to do so, his/her admission shall be cancelled.

4. INTER-UNIVERSITY ORDINANCES

(i) Notwithstanding anything contained in these ordinances a student, who is qualified under the foregoing ordinances for admission to University and who is a member of some other Indian University shall not be admitted to the University or any constituent faculty without the production of:

(a) leaving or transfer certificate signed by the Principal of the College last attended and certifying to the satisfactory conduct of the student mentioning the highest examination he/she has passed, and;

(b) a certified copy of all the entries against his/her name in the enrolment register of the University if such a copy is obtainable.

(ii) A student of some other Indian University shall, in any case, be admitted only at the beginning of the particular degree programme, which he/she proposes to take in the University.

5. SCALE OF TUITION AND OTHER FEES

(i) All regular candidates to be admitted for the M.Sc., M.Sc. (Tech) and M.C.A. programmes shall pay the following fees per Academic Year :

	M.Sc/ M.Sc. (Tech)	**M.C.A.**	**M.Sc. Bioinformatics**
Tuition Fee	250.00	2500.00	250.00
Faculty/Institute Development Fund	250.00	1000.00	3250.00
Lab Fee & Development Fund*	600.00	3500.00	3500.00
Academic Assessment#	250.00	250.00	700.00
Library Fee & Development Fund	200.00	2500.00	2500.00
Computer & Internet Facility	100.00	100.00	500.00
Student's Health Welfare	280.00	280.00	280.00
Extra Curriculum Activity Fund	170.00	170.00	170.00
Border's/Delegacy Union Fee	10.00	10.00	10.00
Student's Union Fee+	10.00	10.00	10.00
Student's Welfare Fund	100.00	100.00	1000.00
Total	**2220.00**	**10420.00**	**12170.00**
Admission	50.00	50.00	50.00
Enrolment	50.00	50.00	50.00
Identity Card & Passbook	26.00	26.00	26.00
Alumni Activity Fund	50.00	50.00	50.00
Degree Charges	100.00	100.00	100.00
Training & Placement^	100.00	500.00	1500.00
Library Caution Money	500.00	500.00	500.00
Total	**876.00**	**1276.00**	**2276.00**
Grand Total	**3096.00**	**11696.00**	**14446.00**

*Lab Fee Rs. 40 + Development Fund Rs. 160 = Rs. 200 per subject.
^M.Sc. (Rs. 500/- for Computer Science)
+No Students Union Fee will be realized till the Students Union remains suspended.

Note: **(A)** Fee for Supplementary Examination Rs. 50/- per paper (Rs. 12/- 'R' A/c + Rs. 38/- 'Development Fund')

(B) Cyber hut membership fee @ Rs. 200/- per annum. (Only for M.Sc. Bioinformatics, MMV)

Hostel Fee	Indian Nationals	Foreign nationals
Hostel Rent*	160.00	300.00
Fan Fee	100.00	100.00
HDMF	2000.00	2400.00
Mess Caution Money	800.00	1000.00
Fan Caution Money	1000.00	1000.00
Hostel Annual Maintenance Fee	50.00	50.00
Hostel Establishment Charges	0.00	100.00
Hostel Development Charges	0.00	500.00
I.H. Annual Maintenance Fund	0.00	2400.00
Total	**4110.00**	**7850.00**

* Rs. 500/- will be charged from four Hostellers (viz. Triveni, Sardar Patel, Atreya and Sukanya) separately

Note: The above fees may be revised by the Academic Council from time to time.

(ii) The fees for Special Courses shall be charged as decided by the Academic Council from time to time.

6. SYSTEM OF EXAMINATION

1. The examinations of M.Sc./M.Sc.(Tech.)/ M.C.A. Programmes in the Faculty of Science shall be conducted in the four/six semesters, ordinarily in December/May or on such dates as may be fixed by the Dean in the various Programmes/courses taught during that academic year.

2. The academic performance of a candidate shall be evaluated in respect of the courses of study prescribed for each semester of the concerned PG Programme through the examinations held in that semester.

3. The Credit System-

Each course shall have a specified number of credits. These credits describe the weightages of the concerned courses. The number of credits that a student has satisfactorily completed measures the performance of the student. Satisfactory progress of a student is subject to his/ her maintaining a minimum Cumulative Grade Point Average (CGPA). A certain minimum number of credits as specified in the syllabus must be earned by the student to qualify for the degree.

7. Course Structure for the M.Sc. / M.Sc. (Tech.)/ M.C.A. Degree

A. Categories of Courses:

There shall be three categories of courses:

(a) Core Courses
(b) Major Electives (Specialization, if desired)
(c) Minor Electives

The minimum credit requirement for the two-year M.Sc. Degree in the Faculty of Science shall be 90 credits and for a 3-year degree it shall be 135 credits. A student shall be permitted to register for a minimum of 20 credits and for a maximum of 28 credits per semester. The three types of courses shall have the distribution of credits as given below:

	(1) For Two-Year Degree Programmes	**Credits**
(i)	Core Courses and Major Electives (specialization)	81
(ii)	Minor Electives (Total)	09

	(a) From other Departments/ PG Programmes within the Faculty	06-09*
	(b) From within the same Department/ PG Programme	03 (Maximum)*

	(2) For Three-Year Degree Programmes	**Credits**
(i)	Core Courses and Major Electives (specialization)	126
(ii)	Minor Electives (Total)	09
	(a) From other Departments/ PG Programmes within the Faculty	06-09*
	(b) From within the same Department/ PG Programme	03 (Maximum)*

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* This shall not apply to Bioinformatics, Home Science, Computer Science, Computer applications and Environmental Science and Technology programmes.

Note: The option of the major and minor electives shall be exercised by the student at the beginning of the semester.

B. Minor Elective Courses:

In each of the, preferably, Ist, IInd and IIIrd Semesters, the student shall offer one course of 3 credits as 'minor elective' from any department/ PG programme subject to the conditions described in clause 7.A.

C. Assignment of credits:

Credits of a course shall be assigned in the following manner:

(a) For all theory (Lecture) courses one credit shall be assigned for one one-hour lecture per week in a semester.

(b) Two laboratory hours per week in a semester shall be assigned one credit.

(c) Credits shall be in whole numbers. As far as possible, each theory course shall be of 3 Credits (minimum), while each laboratory course shall be of minimum 2 Credits.

8. <u>The Performance of a candidate in a semester or upto a semester shall be measured by SGPA and CGPA, details of which are given below:</u>

SGPA : Semester Grade Point Average.

CGPA : Cumulative Grade Point Average.

<u>Calculation of Semester Grade Point Average (SGPA)</u>

<u>and Cumulative Grade Point Average (CGPA):</u>

$$\text{(i). SGPA} = \frac{\sum_{i=1}^{n} Ci.Pi}{\sum_{i=1}^{n} Ci}$$

where,

Ci = Number of credits assigned for the ith course of a semester for which SGPA is to be calculated.

Pi = Grade point earned in the i^{th} course.

i = 1, ------- n, represent the number of courses in which a student is registered in the concerned semester.

Note: *For calculation of SGPA and CGPA, credits of compulsory and optional courses shall not be taken into account.*

$$\text{(ii). CGPA} = \frac{\sum_{j=1}^{m} Cj.Pj}{\sum_{j=1}^{m} Cj}$$

where,

Cj = Number of credits assigned for the j^{th} course, up to the semester for which CGPA is to be calculated.

Pj = Grade point earned in j^{th} course.

j = 1, ------- m; represent the number of courses in which a student was registered up to the semester for which CGPA is to be calculated.

(C) <u>Grading System:</u> The grading system, as detailed hereunder in **Table 1** shall be applicable for each course:

Table - 1

Award of Grades Based on Absolute Marks

Marks Range (Out of 100)	**Grade**	**Grade Point**
90 -100	S	10
80 - 89	A	9
70 - 79	B	8
60 - 69	C	7
50 - 59	D	6
40 - 49	E	5
Passed with Grace	P	4
00 - 39	F	0
Non-appearance in examination (Incomplete)	I	0
Incomplete Project / Dissertation / Training	X	0

Explanation:

Latter grades **S, A, B, C, D, E and P** in a course mean that the candidate has passed that course.

The F grade denotes poor performance, i.e., failing in the course. A student has to appear at subsequent examination(s), if provided under the ordinances in all courses in which he/she obtains "F" grade, until a passing grade is obtained.

The I Grade: The "I" Grade is awarded, when a student does not appear in the examination of course/courses. This shall be treated as "F" Grade.

The X Grade: An "X" Grade is awarded to a student if he/she does not complete Project/Dissertation/Training. This will be converted to a regular grade on the completion of the Project/Dissertation/Training Work and its evaluation. The "X" Grade shall be treated as "F" Grade.

C. Grace Rule: Tabulators shall award grace marks as per the following guidelines:

(1). A student who fails in not more than 3 theory courses by total marks of not more than ½ the number of total theory courses of the semester (any) fraction is rounded off to the next higher number), shall be awarded grade "P" (in place of grade "F") of Grade Point 4 in the concerned courses.

(2). Grace mark will not be awarded for making up shortfall in minimum SGPA/CGPA or improving the grade.

Confidential Clause

9. Examination System:

Each theory/ practical/ seminar/ field work/ project/ dissertation course shall be of 100 marks. For evaluation, the overall structure of the distribution of marks in a course shall be such that 30 marks are allotted to various assessments during the semester, while 70 marks shall be allotted for the end semester examinations.

(i). The scheme of assessment during the semester (for 30 marks):

(a) The assessment (sessional) in theory courses shall comprise a class test of 1 hour duration for 20 marks and 10 marks for regularity/ assignment/viva/quiz/or any other similar test.

The 30 marks of sessional for courses of Laboratory exercises shall be based on completion of the laboratory exercises in due course of time/keeping up of practical record book/punctuality in the class/viva to the practicals/ any other relevant judgment.

(b) At the discretion of the concerned Head/Coordinator, a student who could not appear in the internal test(s) already conducted on account of some cogent reasons, such as late admission, illness etc., may be allowed to appear in the internal assignment/test held for such a student.

(c) The class tests shall be conducted by the teacher (or group of teachers) teaching the course and the marks shall be displayed on the Notice Board.

(d) All Heads/Coordinators shall ensure that all internal assessment marks of sessionals are sent to Controller of Examination prior to the commencement of End Semester Examination.

(e) There shall not be any sessional marks for courses, which involve Seminar/ Field work/ Project Work/ Dissertation.

(f) Sessional marks of a course shall be carried over for failed students in the course.

(ii) End Semester Examination and evaluation (for 70 marks):

(a) The question papers shall be set and the answer-scripts shall be evaluated by the teachers of the concerned courses. If there are more than one teacher teaching the course, the question paper shall ordinarily be set and evaluated by a teacher of the group, appointed by the Board of Examiners.

(b) The End Semester examination answer-scripts shall be shown to the students after evaluation by the concerned teachers within 7 days of the last examination for the semester. Thereafter, within a week, all the answer books along with the statement of marks shall be sent by the examiner to the Office of the Controller of Examinations for declaration of the results.

(c) In case of any objection by a student in the evaluation, the same shall be looked after by a panel of two senior faculty members, to be nominated by the Dean, whose decision shall be final.

(d) In cases of practical examination and project/ dissertation evaluation, external examiner may be appointed if and where considered necessary.

(e) There shall be no provision for re-evaluation.

(iii) Admit Card (for End Semester Examinations):

A candidate may not be admitted into examination room unless he/she produces his/her admit card to the officer conducting the examination or satisfies such officer that it will be subsequently produced.

The Controller of Examinations may, if satisfied that an examinee's admit card has been lost or destroyed, grant duplicate admit card on payment of a further fee of Rs. 10/-

10. PROMOTION RULES AND SUPPLEMENTARY EXAMINATION

1. 2-YEAR M.Sc. (FOUR SEMESTER) PROGRAMMES

There shall be no supplementary examination for Ist & IInd semesters. However, there shall be supplementary examination for IIIrd and IVth semesters after declaration of the results of IVth Semester. Students failing in courses of IIIrd and IVth semesters may appear in supplementary examination(s) or subsequent main examination(s).

(A) ***First Semester Course & Examination:***

The candidates who have taken admission in the First Semester of a 2-year M.Sc. programme in a session can be put in the following two categories on the basis of their attendance in the Semester:

I. (i) Those who have put in the required minimum percentage of attendance for appearing in the First Semester Examination and filled up the examination form in time for appearing at the First Semester Examination.

(ii) Those who did not put in the required minimum percentage of attendance for appearing at the First Semester Examination or did not fill up examination form in time for appearing at the First Semester Examination.

Candidates under Category I(i) are eligible for appearing at the examination of First Semester, while ***candidates under Category. I(ii)*** are not allowed to appear at the examination of the Semester. However, category ***I(ii)*** candidates

are allowed to reappear at the Post-graduate Entrance Test (PET) of subsequent year(s) for seeking admission afresh. This implies that **no readmission is permissible to those who do not put in the required percentage of attendance for taking the examination or did not submit the examination form in time**.

II. After appearing at the Examination of First Semester the candidates can be put in the following categories in the context of declaration of the results of the First Semester Examination:

(i) **Passed,** i.e., those who have passed in examinations of all courses of the Semester.

(ii) **Promoted,** i.e., those who have not passed in examinations of all the courses of the Semester.

(iii) **Minimum passing grade** – Grade 'E' for each course. However, candidates with grade 'P' in a course shall also be considered as passed in that course.

(iv) **Promotion to Second Semester**:

All students who have put in the minimum percentage of attendance in Semester I and filled up the examination form in time shall be promoted to the Semester II.

(B) Second Semester Course & Examination:

As in the First Semester, in all subsequent Semesters, all the candidates who have put in the minimum percentage of attendance for appearing at the Examination and have filled in the examination form in time for appearing at the End Semester Examination shall be allowed to appear at the respective examinations. However, students who have not put in the minimum percentage of attendance or did not fill up the Examination form in time in Semester shall be allowed to take re-admission in that Semester **(except in the First Semester where re-admission is not permitted)**.

(C) Declaration of results after IInd Semester (based on the results of Ist and IInd Semester Examinations):

After declaration of results of the First & Second Semesters, a candidate can be put in the following categories:

(i) **Passed:** A candidate who has passed in examinations of all the courses of the First & Second Semesters.

(ii) **Promoted:** A student, who has not passed in all the courses of either Ist or IInd semester or both, shall be promoted to the IIIrd semester if he/she has obtained at least 4.0 CGPA. All such students shall have the option to clear the courses, in which they had failed, in the subsequent available examination(s) of the concerned semester as ex-students.

(iii) Failed: A candidate who has failed in one or more courses or failed to appear at any of the examinations of Ist and IInd Semesters taken together, and has obtained less than 4.0 CGPA shall be treated as failed.

Note: *There shall be no supplementary examination for the courses of Ist and IInd semesters.*

(D) Promotion to the Third Semester:

(i) A candidate who comes under the category **'Passed or Promoted'** is eligible to be promoted to the third Semester, if otherwise eligible.

(ii) Failed candidates shall not be promoted to the IIIrd Semester. However, they shall be promoted to the third semester when they become eligible to come under the category of either 'Passed' or 'Promoted' as explained above after passing the failed courses in the subsequent available examination(s) as ex-students.

(E) Promotion to the Fourth Semester:

All students who have put in the minimum percentage of attendance in IIIrd Semester and filled in the examination form in time shall be promoted to the IVth Semester.

(F) Declaration of Results after Fourth Semester (Based on the results of the I^{st,} IInd, IIIrd and IVth Semester Examination):

After declaration of results of IIIrd and IVth Semesters, a candidate can be put in the following two categories:

(i) **Passed:** A candidate who has passed in all the courses of I, II, III and IV Semesters and obtained at least CGPA of 5.0.

(ii) **Failed:** All those students who have not "Passed" shall be categorized as "Failed".

Such failed students may clear their failed courses in subsequent examinations as ex-students. There shall be a provision of supplementary examinations for III and IV Semesters after declaration of results of IV Semester. Students failing in courses of III and IV Semesters may appear in the supplementary examination or subsequent main examination(s).

A student who has failed in a course shall get two more chances to clear this course subject to the maximum duration for passing the course. Further, each candidate shall have to clear all the courses within the maximum period of 4 years from the date of his/her latest admission.

(G) Maximum duration for passing the PG Programme:

The maximum duration for passing the 2-years PG programme shall be 4 years, which shall be counted from the year of latest admission in the Ist semester of the PG programme. No student shall be allowed to take further admission in the programme after the expiry of four years.

(H) Deposition of Fees:

All students eligible for promotion to third semester shall deposit the requisite fee for semesters 3 & 4 (Second academic year) within the time prescribed by the University.

2. 3-Year M.Sc. (Tech.) and MCA Programmes

Rules for promotion up to the IVth semester shall be the same as those for the 2-year M.Sc. Programmes of the Faculty. However, there shall be no supplementary examination for Ist, IInd, IIIrd and IVth semesters. But there shall be supplementary examination for Vth and VIth semesters after declaration of the results of the VIth Semester. Students failing in courses of Vth and/ or VIth semesters may appear in supplementary examination(s) or subsequent main examination(s).

(a) Promotion to the Vth Semester

A student who passes in all the courses of Ist, IInd, IIIrd & IVth semesters shall be promoted to the Vth semester.

A student who has not passed in all the courses of the above examinations shall also be promoted to the Vth semester if his/ her CGPA (up to the IVth semester) is at least 4.0.

Students not securing atleast 4.0 CGPA up to the IVth Semester will be treated as failed and such failed students will not be promoted to Vth Semester until they obtain at least 4.0 CGPA up to the IVth Semester after passing all/ some failed courses in the subsequent- available examination(s) as ex-students.

(b) Promotion to the VIth Semester

A student who has put in at least the required minimum percentage of attendance in the Vth Semester and has filled up the examination form in time shall be promoted to the VIth semester.

(c) Declaration of Results after the VIth Semester:

After declaration of results of Fifth and Sixth Semesters, a candidate can be put in the following two categories:

(i) **Passed:** A candidate who has passed in all the courses of I, II, III, IV, V & VI Semesters and obtained at least CGPA of 5.0.

(ii) **Failed:** All those students who have not "Passed" shall be categorized as "Failed".

Such failed students may clear their failed courses in subsequent examinations as ex-students. There shall be a provision of supplementary examinations for V and VI Semesters after declaration of results of VI Semester. Students failing in courses of V and VI Semesters may appear in the supplementary examination or subsequent main examination(s).

A student who has failed in a course shall get two more chances to clear this course subject to the maximum duration for passing the course. Further, each candidate shall have to clear all the courses within the maximum period of 6 years from the date of his/her latest admission.

(d) Maximum Duration:

Maximum duration for passing of the 3-years PG programme shall be 6 years, which shall be counted from the year of the latest admission in the Ist semester of the programme. No student shall be allowed to take further admission in the programme after the expiry of the six years.

11. <u>Declaration of Division</u>

A candidate who has passed in all the papers/ courses of Ist, IInd, IIIrd and IVth Semesters of 2-year PG programmes or Ist, IInd, IIIrd, IVth, Vth and VIth semesters of the 3-year PG programmes taken together shall be declared as 'Passed'. Such passed candidates may be awarded with the division according to the following criteria:

(i) First Division with distinction : CGPA 8.5 and above
(ii) First Division : CGPA 6.5 and above, but below 8.5
(iii) Second Division : CGPA 5.0 and above, but below 6.5

Note: The SGPA and CGPA shall be computed upto 2 places of decimals (truncated at the second place).

The conversion formula for converting CGPA to the corresponding Percentage of Marks will be as follows:

$$X = 10 Y - 4.5$$

where, X = Percentage of Marks

Y = CGPA

12. Further Clarification

A student who is promoted to a higher semester or readmitted to a semester due to shortage of attendance shall be required to study the same syllabus as being taught in that year.

13. Syllabus

The syllabi for the various PG programmes shall be framed by the Department/ School concerned.

14. Ranking to the candidates

Ranking shall be given to only those candidates who pass all the courses of the programme in one attempt.

Notwithstanding any provision in the ordinances to the contrary, the following category of examinee is also eligible for ranking:

The student who, having been duly admitted to a regular examination of the programme, was unable to take that examination in full or in part due to some disruption of examination, and took the next following examination of that programme and passed the course(s).

The marks obtained by him/her at the examination shall be considered as the basis for the University Ranking, Scholarships and other distinctions.

In order to get the benefit of this provision, the student should claim that he/she is eligible for this benefit and get a decision in writing after proving his/her eligibility therefore.

15. Re-admission to the Programme/semester

A student who does not put in at least the minimum percentage of attendance required in the Ist semester shall not be promoted to the higher semesters. However, such students can take fresh admission in the PG programme after appearing in the PET of Faculty of Science and being eligible for admission in the course on the basis of result of the PET of the concerned year.

All such students of IInd, IIIrd, IVth, Vth or VIth semesters who have not put in the required minimum percentage of attendance or not filled in the examination form in time shall have the option to be re-admitted in the concerned semester available in the subsequent year(s). No student who has been promoted to the IInd or higher semester and continues to be a student shall be allowed to reappear in the PET of the same programme for taking fresh admission in the programme.

16. Break in the Course

Any student taking admission in any of the M.Sc./ M.Sc. (Tech.)/ MCA programmes of the Faculty shall not be allowed to pursue any other full time programme/ course in the Faculty or elsewhere in the entire period of the programme meaning thereby that if a student leaves the programme after passing some of the semesters/ courses and takes up a full-time programme/ course elsewhere, then he/she shall not be allowed to continue the programme further in the Faculty.

Definition

1. A 'Regular Student' is one who has pursued a regular programme of study and obtained prescribed attendance mentioned in the ordinances and is eligible to appear in the examination.

2. 'Ex-student' means one who has studied in the Faculty/MMV for at least one semester preceding the date of the examination and had filled up the examination form but failed or had failed to appear in the examination, though otherwise eligible.

Note: *Academic calendar for the odd and even semesters shall be notified at the beginning of every academic year.*

M. Sc. APPLIED MICROBIOLOGY

Department of Botany
Banaras Hindu University

Special Course of Study

Candidates who have passed B. Sc. with 10+2+3 examination with any two of the following subjects Botany, Zoology, Biotechnology, Microbiology, Chemistry, Industrial Microbiology, Life Sciences and Environmental Sciences and secured at least 50% marks in aggregate, shall be considered eligible for admission to M. Sc. Course in Applied Microbiology. In addition, students who have passed B.Sc. (Agriculture) shall also be eligible for admission to the course.

1. There shall be four semesters.
2. There shall be twelve core courses; each core course will have 5 credits (3 credits for theory and 2 credits for practical).
3. Candidates will select two minor elective courses from outside the Applied Microbiology course and one from Applied Microbiology course of 3 credits each and that will be based on only theory.
4. The dissertation work will be carried out by the students in the 3rd semester at BHU, any other university or industry, and this would include submission of dissertation and viva-voce examination.
5. The dissertation and presentation will be evaluated by the internal and external examiners who will also conduct viva-voce examination.

The distribution of credits will be as follows:

Semesters	No. of papers			No. of credits		
	Theory	**Practical**	**Total**	**Theory**	**Practical**	**Total**
I	05	02	07	15	08	**23**
II	05	02	07	15	08	**23**
III	00	02	02	03	21 15*+06**	**21**
IV	05	02	07	15	08	**23**
Total	15	08	23	45	45	**90**

*Dissertation
**Presentation

Minor electives:
1: Microbial Diversity, management & Exploitation (for students of Applied Microbiology also)
2: Microbial Biogeochemistry (for students of other M.Sc. courses)
3: Cyanobacterial Biotechnology (for students of other M.Sc. courses)

DISTRIBUTION OF DIFFERENT COURSES AND CREDITS IN VARIOUS SEMESTERS

FIRST SEMESTER	SUBJECTS	CREDIT	TOTAL CREDITS
CORE COURSE			
AM 1	General Microbiology	3	**23**
AM 2	Microbial and Enzyme Technology	3	
AM 3	Microbial Physiology and Biochemistry	3	
AM 4	Microbial Genetics	3	
Practicals	Based on AM 1 & 2	4	
	Based on AM 3 & 4	4	
Minor Elective	Open to students	3	
SECOND SEMESTER			
CORE COURSE			
AM 5	Biochemical and Molecular Techniques	3	**23**
AM 6	Immunology	3	
AM 7	Microbial Genomics	3	
AM 8	Environmental Microbiology & Wastewater Management	3	
Practicals	Based on AM 5 & 6	4	
	Based on AM 7 & 8	4	
Minor Elective	Open to students	3	
THIRD SEMESTER			
	Dissertation	15	
	Presentation & Viva-Voce	6	**21**
FOURTH SEMESTER			
CORE COURSE			
AM 9	Bioprocess Technology & Engineering	3	**23**
AM 10	Medical Microbiology	3	
AM 11	Agricultural Microbiology	3	
AM 12	Food and Dairy Microbiology	3	
Practicals	Based on AM 9 & 10	4	
	Based on AM 11 & 12	4	
*Minor Elective	Open to students	3	
		TOTAL CREDIT	**90**

Minor electives: 3 credits each

1: Microbial Diversity, Management & Exploitation (for students of Applied Microbiology as well)

2: Microbial Biogeochemistry **(for students of other M.Sc. courses)**

3: Cyanobacterial Biotechnology **(for students of other M.Sc. courses)**

Note: Semester in whicha given minor electives course will be offered will be decided as per needs and facilities in the Department.

AM 1: General Microbiology

History of Microbiology.
A brief idea of microbial diversity and scope of microbiology.
Principles of classification of microbes; morphological, metabolic and molecular criteria for the classification, a brief introduction to major group of bacteria.
Nutritional types of microorganisms.
Structure of Gram positive and Gram negative bacteria; cell membrane, cell wall, flagella, capsule and slime, chromosome, ribosome, plasmid and endospores.
A brief account of genetic recombination in bacteria (transformation, conjugation and transduction).
A general idea of structure of different kinds of viruses; structure of bacteriophages belonging to 'T' series.
Lytic cycle in T even phages and its regulation; lysogeny and its regulation in lambda phage; a brief account of viroids and prions.

AM 2: Microbial and Enzyme Technology

Enzymes from microbial sources, large scale production of enzymes, recovery of enzymes, enzyme purification methods - enzyme precipitation, separation by chromatography, enzyme reactors.
Immobilized enzymes: Physical and chemical methods of immobilization, immobilization supports, kinetics of immobilized enzymes.
Enzyme catalysis in apolar medium, reverse micellar entrapment of enzymes and its applications.
Application of enzymes: synthesis of chemicals using enzymes, food technology and medicine.
Enzymes in diagnostic assays.
Enzyme electrodes, immunoenzyme techniques.
Commercial products of microbes: Antibiotics, biopolymers, biosensors, biopesticides
Production of biofuels.
Microbial toxins: Types, biochemical and molecular basis of toxin production, implications.
Genetically engineered microbes, anti-HIV, anticancer, antifungal, antiplasmodial, anti-inflammatory compounds.

AM 3: Microbial Physiology and Biochemistry

Overview: Scope and importance
Structure and function of biomolecules: Carbohydrates, proteins, lipids
Enzymes: Characteristics, Ribozymes, co-enzymes, kinetics-M-M equation, determination of K_m and V_{max}, mechanism of action - binding of substrate and lowering of activation energy, covalent catalysis, acid- base catalysis, allosteric regulation, enzyme inhibition.
Metabolism: General concepts - application of second law of thermodynamics, redox potential, outline of intermediary metabolism: free energy change of the reactions catabolism – anabolism, ATP as high energy phosphate compound, ATP synthesis
Bacterial photosynthesis,
Assimilation of sulphur, phosphorus and nitrogen.
Biochemical basis of actions of antimicrobial agents.

AM 4: Microbial Genetics

Nucleic Acids: Structure, physical and chemical properties of DNA and RNA, extra-chromosomal DNA- profile, function and evolution.

DNA replication, damage and repair, spontaneous and induced mutation, reversion of mutation.
Transposition: Structure of transposons, replicative and non-replicative transposition, transposon mutagenesis.
Genetic recombination; Molecular models and mechanism, Gene conversion.
Gene expression and regulation: Operons and regulons, repression and activation of *Lac operon*, feed back inhibition and regulation of virulence genes in pathogenic bacteria.
Signal transduction in microbes.
Use of microbes in genetic engineering.

AM 5: Biochemical and Molecular Techniques

Electrophoresis: Polyacrylamide gel electrophoresis (PAGE), agarose gel electrophoresis, native PAGE, SDS-PAGE, 2D electrophoresis, mass spectrometry.
Isolation and purification: (a) genomic and plasmid DNA, (b) RNA, (c) proteins.
Isoelectric focusing (IEF): Principles, kinds of pH gradients used in IEF-free carrier ampholytes, immobilized pH gradients.
Blotting: Principles, types of blotting, immunoblotting- Southern, Northern, Western and Dot blots.
DNA amplification: PCR, RT- PCR.
DNA sequencing: Various methods of DNA sequencing.
Gene silencing: RNA interference (RNAi).
Chromatography: Gel filtration, ion exchange & affinity chromatography, TLC, HPLC, GC-basic concept.
Spectroscopy: Basic concept, NMR & ESR spectroscopy.
Microscopy: Phase contrast, confocal, fluorescence, scanning & transmission electron microscopy.
Bioinformatics: Databases, sequence analysis, phylogenetic inference package, sites and centres.

AM 6: Immunology

Introduction to immune system: Innate and adaptive immune responses; Cells and organs of immune system; hematopoiesis; Antigens, haptens, adjuvants immunoglobulins and monoclonal antibodies; B and T cell interaction.
Antigen antibody interactions and its applications.
Immunoglobulin and TCR genes and generation of diversity: Organization of Immunoglobulin genes; V(D)J rearrangements; somatic hypermutation and affinity maturation; immunoglobulin gene expression and its regulation; organization of TCR genes and mechanisms of diversity.
Major histocompatibility complex: Generation of humoral and cellular immune responses and effector mechanisms; antigen processing and presentation; immunological memory; complement system; action of cytotoxic T lymphocytes; Natural killer cells, ADCC.
Immunological tolerance.
Immunology in health and disease- autoimmunity, immunodeficiencies hypersensitivity; concept of immunotherapy.

AM 7: Microbial Genomics

Tools for studying DNA/genes: Enzymes for DNA manipulation, molecular cloning, DNA libraries, fluorescent in situ hybridization (FISH), denaturing gradient gel electrophoresis (DGGE).

Genomes: Size, physical structure, genome analysis, gene duplication.
Mapping of genome: Molecular markers as tools for mapping, restriction fragment length polymorphism (RFLP), randomly amplified polymorphic DNA (RAPD), simple sequence length polymorphism (SSCP), amplified fragment length polymorphism (AFLP).
Functional genomics: entire genome expression analysis-microarrays, expressed sequence tags (ESTs), serial analysis of gene expression (SAGE), single nucleotide polymorphism (SNP).
Proteomics- basic concept and importance.

AM 8: Environmental Microbiology & Wastewater Management

Aeromicrobiology: Microorganisms in outdoor atmospheric environment, nature of bioaerosols, their fate and transport.
Aeromicrobiology: Microorganisms in indoor environment - buildings, spaceflights, hospitals and laboratories.
Microorganisms in soil-environments: Surface, subsurface and deep soil conditions.
Microorganisms in various aquatic environments: Freshwater, brackish-water, marine-water and subterranean conditions.
Brief introduction to thermophiles, barophiles, acidophiles, alkalophiles and psychrophiles.
Role of microorganisms for biomonitoring of various quality-parameters related to water and wastewater - Indicator organisms, single species laboratory bioassays and biosensors.
Brief introduction to various stages of wastewater treatment: Primary, secondary and tertiary treatment.
Batch and continuous reactor-systems: Attached growth and suspended culture systems, stabilization ponds.
Control of pathogens in water and wastewater.
Use of microorganisms for removal of various toxins and metallic ions from wastewater.

AM 9: Bioprocess Technology and Engineering

An introduction to fermentation processes- Range of fermentation process, microbial biomass, microbial enzyme, microbial metabolites, and transformation processes.
Microbial growth kinetics- Batch culture, continuous culture, industrial applications of continuous culture processes, fed-batch culture.
The isolation, preservation and improvement of industrially important and useful microorganisms.
Media for industrial fermentation- typical media, media formulation, water, energy and carbon sources, nitrogen sources, minerals, vitamin sources, nutrient recycle, buffers, precursors and metabolic regulators, oxygen requirement.
Sterilization of air and media- Media sterilization, batch and continuous media sterilization processes, sterilization of fermenter, sterilization of the feeds, sterilization of air, theory of fibrous filters, filter design.
The development of inocula for industrial fermentation- development of inocula for yeast, bacteria, fungal and actinomycetes processes, the inoculation of fermenters.
Design of fermenter- Basic functions of a fermenter, construction, aeration and agitation, baffles, the achievement and maintenance of aseptic conditions, valves, other fermentation vessels.
Aeration and agitation- The oxygen requirements of industrial fermentation processes, determination of KLa, factors affecting KLa, fluid rheology.
Instrumentation and control- Control systems, manual, automatic, methods of measurements of process variables, flow, temperature, pressure, agitator shaft power, foam sensing and

control, measurement and control of dissolved oxygen, on-line analysis of process parameters, computer control of fermenters.

AM 10: Medical Microbiology

General topics on Medical Microbiology: History, Koch's postulates microbiology and medicine, classification of medically important bacteria; Morphology and growth and nutrition of bacteria, infection - source, modes of transmission, portal of entry into the susceptible host, prevention; bacterial pathogenicity; identification of bacteria - staining methods, culture methods, biochemical tests other recent methods; sterilization and disinfection; normal microbial flora; antimicrobial agents, drug resistance and drug sensitivity test.

Systematic Microbiology: Diseases caused by Gram positive cocci - sore throat, pneumonia etc.; diseases caused by Gram negative cocci - meningitis, gonorrhea; diseases caused by Gram positive bacilli - tuberculosis, diphtheria, tetanus, gas gangrene etc.; diseases caused by Gram negative bacteria of family Enterobacteriaceae - enteric fever, bacillary dysentery, UTI etc.; diseases caused by other Gram negative bacilli - cholera, plague, whooping cough, wound infection, septicemia etc.; sexually transmitted diseases; diseases caused by mycoplasma, Chlamydia, rickettsia; overview of medical mycology – superficial, subcutaneous, systemic and opportunistic mycosis; overview of medical parasitology: Important protozoal diseases: Malaria, Leishmaniasis, amoebiasis giardiasis etc., and helmenthic diseases: Ascariasis, Ankylostomiasis, filariasis, Taeniasis, Echinococcosis, Schistosomiasis etc. Overview of medical virology: (Herpesvirus, Poliovirus, Rabiesvirus, Arboviruses, Hepatitis, HIV etc.). Bacteriology of water, milk and air; opportunistic infections, Immunoprophylaxis.

AM 11: Agricultural Microbiology

Soil microorganisms in agro ecosystems: Types of microbial communities; soil microbial diversity: significance and conservation; effect of agricultural practices on soil organisms.

Biological nitrogen-fixation: The range of nitrogen fixing organisms; mechanism of nitrogen fixation (biochemistry of nitrogenase); genetics of nitrogen-fixation; *Rhizobium*-Legume Association; Symplasmids, N_2 fixation by non-leguminous plants. Chemical transformation by microbes: Organic matter decomposition, nutrient mineralization and immobilization; transformation of carbon and carbon compounds; availability of phosphorus, sulfur, iron and trace elements to plants; biodegradation of herbicides and pesticides.

Biofertilizer: Mass cultivation of microbial inoculants; green manuring; algalization; *Azolla*.

Microbial products and plant health: PGPR (plant growth promoting rhizobacteria); significance of mycorrhizae; toxin producing microbes (antibiotics, aflatoxin, etc.); microbial herbicides; biological control.

AM 12: Food and Dairy Microbiology

Microbiology of food items; Fermented food, wine, bakery products, cereals, and milk products.

Microbial spoilage of food products including cereals, fruits, vegetables, meat, fish, and dairy products.

Microbiological examination of milk and milk products, source of their contamination and control.

Starter cultures

Microbiological legal standards of selected food and milk products.

Food poisoning and microbial toxins produced in food items and dairy products

Food preservatives and their uses.
Mushroom cultivation technology and single cell protein

M I N O R E L E C T I V E S

MIE1: Microbial Diversity, Management and Exploitation

The microbial world: Major domains and their general characteristics
General concepts regarding biodiversity: Definition, diversity indices and diversity gradients.
Exploration and quantification of the microbial diversity: Cultivation and non-cultivation approaches; complementarity between cultivation and non-cultivation approaches; the relevance of classical taxonomy of the postgenomic era; role of genomics in higher order classification, species concept in microbial world.
Microbial diversity and ecosystem function-theories/hypotheses and experimental results.
Management and exploitation of microbial diversity.
Use of microbes in environmental bioremediation

MIE 2: Microbial Biogeochemistry

The role of microbes in biosphere: microbes and the origin and evolution of life on earth.
Microbial crusts: Characteristics and formation; composition; functions; response to disturbance.
Microbial aspects of biogeochemical cycling of C, N, P and S.
Survival strategies of microbes in extreme habitats.

Microbial mediation of dissolution and precipitation of economically important minerals.

MIE 3: Cyanobacterial Biotechnology

Mass cultivation of cyanobacteria under outdoor and indoor conditions.
Cyanobacteria as a source of fine chemicals, polysaccharides, bioactive molecules, pigments, antioxidants, lipids and polyunsaturated fatty acids.
Cyanobacteria as biofertilizer for paddy cultivation.
Hydrogen production by cyanobacteria: Mechanism, progress and prospects.

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M. Sc. BIOCHEMISTRY
Department of Biochemistry
Banaras Hindu University

Semesterwise distribution of Courses and Credits

SEMESTER - I

Course Code	Title	Credits
BCM 101	Cell Biology and Physiology	4
BCM 102	Bioanalytical Techniques	4
BCM 103	Methods in Molecular Biology	4
BCM 104M #	Biomolecules & Microbial Biochemistry (*for students of other PG programmes)* *Minor Elective (for Biochemistry students)*	3
BCM 105	Practical: Bioorganic Preparations	3
BCM 106	Practical: Analytical Biochemistry	3
	Total	**21**

SEMESTER - II

BCM 201	Bioenergetics and Metabolism I	4
BCM 202	Metabolism II	4
BCM 203	Immunology	4
BCM 204M #	Nutritional Biochemistry (*for students of other PG programmes)* *Minor Elective (for Biochemistry students)*	3
BCM 205	Practical: Bioanalytical Techniques	3
BCM 206	Practical: Microbiology and Immunology	3
BCM 207	Assignment based Seminar - I	2
	Total	**23**

SEMESTER - III

BCM 301	Enzymology	4
BCM 302	Plant Biochemistry	4
BCM 303	Clinical Biochemistry	4
BCM 304M	Neurobiochemistry *(for Biochemistry students only)*	3
BCM 305	Practical: Enzymology	3
BCM 306	Practical: Enzyme Technology	3
BCM 307	Assignment based Seminar - II	1
	Total	**22**

SEMESTER - IV

BCM 401	Molecular Biology	4
BCM 402	Outlines of Biotechnology	4
BCM 403	Practical: Biochemical Preparations	3
BCM 404	Practical: Clinical Biochemistry	3
BCM 405	Assignment based Seminar - III	2
BCM 406	Project Work Including Presentation, Comprehensive viva	8
	Total	**24**
	TOTAL CREDITS	**90**

M.Sc. Biochemistry students will opt 2 Minor Electives (3 Credit each in Semester I & II, respectively) offered by other PG Programmes of Faculty.

SEMESTER – I

BCM 101: CELL BIOLOGY AND PHYSIOLOGY Credits – 4

1. **Cell Biology** - Cell classification, cell variability (size, shape, complexity, functions). Structural organization of prokaryotic and eukaryotic cells. The ultra structure of nucleus, mitochondria, endoplasmic reticulum (rough and smooth), Golgi apparatus, lysosomes & peroxisomes and their functions. The cytoskeleton – microtubules and microfilaments. Cell movement and chemotaxis.
2. **Blood -** Composition and functions of plasma, erythrocytes including Hb, Leucocytes and thrombocytes, plasma proteins. Blood Coagulation – mechanism and regulation. Transfer of blood gases – Oxygen and carbon dioxide, role of 2,3-diphosphoglycerate, Bohr effect and chloride shift.
3. **Digestive system –** Composition, functions and regulation of saliva, gastric, pancreatic, intestinal and bile secretions. Digestion and absorption of carbohydrates, lipids, proteins, & nucleic acids.
4. **Respiration –** Air passages and lung structure, pulmonary volumes, alveolar surface tension, work of breathing and its regulation.
5. **Endocrine system –** Secretion and functions of hormones of thyroid, pituitary and gonads. Role of hormones in reproduction. Mechanism of action of hormones.
6. **Excretory system –** Structure of nephron, glomerular filtration, tubular reabsorption of glucose, water and electrolytes. Tubular secretion. Homeostatic regulation of water and electrolytes, Acid-base balance.

BCM 102: BIOANALYTICAL TECHNIQUES Credits – 4

1. **Spectroscopy -** Concepts of spectroscopy, Laws of photometry. Beer-Lambert's law, Principles and applications of colorimetry. Visible and UV spectroscopy, ORD, CD, X-ray diffraction, X-ray absorption and NMR.
2. **Chromatography –** Principles and applications of paper, thin layer, ion exchange, affinity, gel permeation, adsorption and partition chromatography. HPLC and FPLC.
3. **Centrifugation –** Principle of centrifugation, concepts of RCF, different types of instruments and rotors, preparative, differential and density gradient centrifugation, analytical ultra-centrifugation, determination of molecular weights and other applications, subcellular fractionation.
4. **Electrophoretic techniques –** Principles of electrophoretic separation. Types of electrophoresis including paper, cellulose, acetate/nitrate and gel. Electroporation, Pulse field gel electrophoresis.
5. **Electron microscopy –** Transmission and scanning, freeze fracture techniques, specific staining of biological materials.
6. **Viscosity –** Viscosity of macromolecules, relationship with conformational changes.

BCM 103: METHODS IN MOLECULAR BIOLOGY Credits – 4

1. **Recombinant DNA methods –** Features of commonly used vectors, strategies for cloning in various vectors and Identification of bacterial colonies containing recombinant plasmids, and bacteriophage vectors. Restriction enzymes.
2. **Construction and analysis of c-DNA and genomic libraries** - Protocols and strategies for c-DNA cloning, analysis of genomic DNA by southern hybridization, amplification of DNA by the polymerase chain reaction, preparation of radio-labeled DNA and RNA probes, synthetic oligonucleotide probes, expression of cloned genes in cultured cells, screening expression with antibodies and oligonucleotides.
3. **DNA sequencing –** Rapid DNA sequencing methods; Maxam-Gilbert technique, Sanger's Dideoxynucleotide sequencing, gene walking, foot printing, RNA sequencing.
4. **Application of recombinant technology –** production of insulin, drug, vaccines, diagnostic probe of genetic diseases. Gene therapy.

5. **Chromatin –** Heterochromatin, euchromatin. Histone and non-histone proteins, general properties of histone, packing density, nucleosomes, size, variable linkers, solenoid structure, packaging of DNA, satellite DNA.
6. **Genes –** Prokaryotic and eukaryotic genes, pseudogenes, split genes, super gene family, transposons, C-value paradox. Reassociation kinetics.
7. **Mutation –** Types of mutations, mechanism of mutation, mutagenic agents. DNA repair: UV repair system in *E. coli*.

BCM 104M : BIOMOLECULES AND MICROBIAL BIOCHEMISTRY Credits – 3
(Minor Elective)

Bio-molecules:

1. **Carbohydrates – S**tructure, reactions and functions of monosaccharides, disaccharides polysaccharides and complex carbohydrates; amino sugars, proteoglycans and glycoproteins.
2. **Lipids -** Classification, structure, properties and functions of fatty acids, essential fatty acids, fats, phospholipids, sphingolipids, cerebrosides, steroids, bile acids, prostaglandins and lipoproteins.
3. **Nucleic acids -** Structure and function of nucleotides. Primary, secondary and tertiary structure of nucleic acids, DNA forms and conformations.
4. **Proteins –** Primary, Secondary, Tertiary and Quaternary structures of proteins.
5. **Enzymes -** Historical perspective, general characteristics, nomenclature, Enzyme classification (specific examples), and Enzyme assays.

Microbial Biochemistry:

6. **Morphology** and **Structure of bacteria**, gram positive and gram negative organisms. Microscopy (Bright field, Dark field, Phase contrast and Fluorescence microscopy), sterilization: physical and chemical methods. Nutritional requirements and growth characteristics of bacteria, media for growing bacteria.
7. **Bacterial toxins –** Classification, structure and mode of action of bacterial protein toxins, enterotoxins.
8. **Viruses –** General structure, properties and classification. Virions, prions, lytic cycle, lysogeny, plasmid.

BCM 105 : PRACTICAL : BIOORGANIC PREPARATIONS Credits – 3

Organic Preparations of:

1. ρ-nitrophenyl acetate
2. An aromatic alpha- and beta-glucoside starting with glucose
3. Dinitrophenyl hydrazone of ascorbic acid or any other ketone
4. Dinitrophenyl derivative of an amino acid
5. Fractionation of egg proteins and its quantification
6. Isolation of casein from milk and its quantification

BCM 106 : PRACTICAL : ANALYTICAL BIOCHEMISTRY Credits – 3

1. Carbohydrates: Qualitative analysis, quantitation of glucose and ribose.
2. Amino acids and proteins: Qualitative analysis, quantitation of proteins and amino acids.
3. Quantitation of free and bound phosphate.
4. Quantitation of vitamin C.
5. Fats: Acid number, saponification and iodine values.

SEMESTER – II

BCM 201 : BIOENERGETICS AND METABOLISM I Credits – 4

1. **Bioenergetics –** Concept of free energy, standard free energy, determination of ΔG for a reaction. Relationship between equilibrium constant and standard free energy change, biological standard state & standard free energy change in coupled reactions. Biological oxidation-reduction reactions, redox potentials, relation between standard reduction potentials and free energy change (derivations and numericals included). High energy phosphate compounds – introduction, phosphate group transfer, free energy of hydrolysis of ATP and sugar phosphates alongwith reasons for high ΔG. Energy charge.
2. **Intermediary Metabolism –** Approaches for studying metabolism.
3. **Coenzymes and Cofactors –** Role and mechanism of action of $NAD^+/NADP^+$, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B_{12} coenzymes and metal ions with specific examples.
4. **Carbohydrates –** Glycolysis, various forms of fermentations in micro-organisms, citric acid cycle, its function in energy generation and biosynthesis of energy rich bond, pentose phosphate pathway and its regulation. Gluconeogenesis, glycogenesis and glycogenolysis, glyoxylate and Gamma aminobutyrate shunt pathways, Cori cycle, anaplerotic reactions, Entner-Doudoroff pathway, glucuronate pathway. Metabolism of disaccharides. Hormonal regulation of carbohydrate metabolism. Energetics of metabolic cycle.
5. **Amino Acids –** General reactions of amino acid metabolism - Transamination, decarboxylation, oxidative and non-oxidative deamination of amino acids. Special metabolism of methionine, histidine, phenylalanine, tyrosine, tryptophan, lysine, valine, leucine, isoleucine and polyamines. Urea cycle and its regulation.

BCM 202 : METABOLISM II Credits – 4

1. **Lipids –** Introduction, hydrolysis of tri-acylglycerols, α-, ß- and ω- oxidation of fatty acids. Oxidation of odd numbered fatty acids – fate of propionate, role of carnitine, degradation of complex lipids. Fatty acid biosynthesis, Acetyl CoA carboxylase, fatty acid synthase, ACP structure and function, Lipid biosynthesis, biosynthetic pathway for tri-acylglycerols, phosphoglycerides, sphingomyelin and prostaglandins. Metabolism of cholesterol and its regulation. Energetics of fatty acid cycle.
2. **Nucleotides –** Biosynthesis and degradation of purine and pyrimidine nucleotides and its regulation. Purine salvage pathway. Role of ribonucleotide reductase. Biosynthesis of deoxyribonucleotides and polynucleotides including inhibitors of nucleic acid biosynthesis.
3. **Biosynthesis of vitamins –** Ascorbic acid, thiamine, pantothenic acid and folic acid.
4. **Biochemistry** of **biological nitrogen fixation**.
5. **Porphyrins –** Biosynthesis & degradation of porphyrins. Production of bile pigments.
6. **Plant Hormones –** Growth regulating substances and their mode of action, molecular effects of auxin in regulation of cell extension, effects of gibberellic, abscisic acids and cytokinins in the regulation of seed dormancy, germination, growth and development.

BCM 203 : IMMUNOLOGY Credits – 4

1. **Introduction to immune system –** Innate and acquired immunity. Structure and functions of primary and secondary lymphoid organs.
2. **Cells involved in immune responses –** Lymphoid cells (B-lymphocytes, T-lymphocytes and Null cells), mononuclear cells (phagocytic cells and their killing mechanisms), granulocytic cells (neutrophils, eosinophils and basophils), mast cells and dendritic cell.
3. **Nature of antigen and antibody –** Immunogenicity vs antigenicity, factors influencing immunogenicity, epitopes, haptens, adjuvants and mitogens. Classification, fine structure and functions of immunoglobulins, antigenic determinants on immunoglobulins, isotypic, allotypic and ideotypic variants.

4. **Generation of Diversity in Immune system –** Clonal selection theory - concept of antigen specific receptor. Organization of immunoglobulin genes: generation of antibody diversity, T-cell receptor diversity.
5. **Immune effector Mechanisms –** Kinetics of primary and secondary immune responses, complement activation and its biological consequences, cytokines and co-stimulatory molecules: role in immune responses, Antigen processing and presentation. Cell signaling – Role of MAP kinases.
6. **Major histocompatibility complex (MHC) genes and products –** Polymorphism of MHC genes, role of MHC antigens in immune responses, MHC antigens in transplantation.
7. **Measurement of antigen–antibody interactions –** Agglutination, precipitation and opsonization, gel diffusion (Ouchterlony double immunodiffusion and Mancini's Radial immunodiffusion), immunoblotting, RIA, ELISA and ELISPOT.
8. **Tolerance vs activation of immune system –** Immune tolerance, hypersensitivity (Types I, II, III, IV).
9. **Disorders of immune system –** Autoimmunity, congenital immunodeficiencies, acquired immunodeficiencies.

BCM 204M : NUTRITIONAL BIOCHEMISTRY Credits – 3
(Minor Elective)

1. **Basic concepts -** Function of nutrients. Measurement of the fuel values of foods. Direct and indirect calorimetry. Basal metabolic rate; factors affecting BMR, measurement and calculation of BMR. Measurement of energy requirements. Specific dynamic action of proteins. Recommended dietary allowances.
2. **Elements of nutrition –** Dietary requirement of carbohydrates, lipids and proteins. Biological value of proteins. Concepts of protein quality. Protein sparing action of carbohydrates and fats. Essential amino acids, essential fatty acids and their physiological functions.
3. **Vitamins –** Dietary sources, biochemical functions, requirements and deficiency diseases associated with vitamin B complex, C and A, D, E & K vitamins.
4. **Minerals –** Nutritional significance of dietary calcium, phosphorus, magnesium, iron, iodine, zinc and copper.
5. **Malnutrition –** Prevention of malnutrition, improvement of diets.

BCM 205 : PRACTICAL : BIOANALYTICAL TECHNIQUES Credits – 3

1. Titration of a weak acid using a pH meter, preparation of buffers
2. Verification of Beer-Lambert's law and estimation of absorption coefficient
3. Paper chromatography – Separation of amino acids and carbohydrates in a mixture
4. Thin layer chromatography of fatty acids.
5. Column chromatography – Separation of a mixture of protein and salt using Sephadex column
6. Electrophoresis

BCM 206 : PRACTICAL : MICROBIOLOGY AND IMMUNOLOGY Credits – 3

1. Preparation of stains and reagents
2. Preparation of various culture media
3. Preparation of broth and slants
4. Sterilization of culture media by autoclave method
5. Sterilization of glassware by hot air oven
6. Isolation and propagation of bacteria
7. Staining of bacteria – Simple staining, differential staining, staining of spores and capsules

8. Determination of growth curve of bacteria
9. Biochemical tests and motility for the identification of bacteria
10. Precipitin reaction by double immunodiffusion and radial immunodiffusion (Ouchterlony and Mancini's methods)
11. Detection of antibodies or antigen by ELISA (Indirect and Sandwich ELISA)
12. Detection of antigens by immunoblotting technique

BCM 207 : ASSIGNMENT BASED SEMINAR - I Credits – 2

SEMESTER – III

BCM 301 : ENZYMOLOGY Credits – 4

1. **Introduction** – IUB enzyme classification (specific examples), enzyme specificity, methods for isolation, purification and characterization of enzymes, tests for homogeneity of enzyme preparation.
2. **Kinetics of enzyme action –** Concept of ES complex, active site, specificity, derivation of Michaelis-Menten equation for uni- substrate reactions. Different plots for the determination of K_m & V_{max} and their physiological significances. Importance of K_{cat}/K_m. Kinetics of zero & first order reactions. Significance and evaluation of energy of activation. Michaelis – pH functions and their significance. Classification of multi-substrate reactions with examples of each class. Derivation of the rate of expression for Ping Pong, random & ordered Bi-Bi mechanisms. Use of initial velocity, inhibition and exchange studies to differentiate between multi-substrate reaction mechanisms. Reversible and irreversible inhibition. Competitive, non-competitive, uncompetitive, linear-mixed type inhibitions and their kinetics, determination of K_i and numerical based on these. Suicide inhibitor.
3. **Mechanism of Enzyme Action –** Acid-base catalysis, covalent catalysis, proximity, orientation effect. Strain and distortion theory. Chemical modification of active site groups. Site directed mutagenesis of enzymes. Mechanism of action of chymotrypsin, lysozyme, glyceraldehyde 3-phosphate dehydrogenase, aldolase, carboxypeptidase, triose phosphate isomerase and alcohol dehydrogenase.
4. **Enzyme Regulation –** General mechanisms of enzyme regulation, product inhibition. Reversible (glutamine synthase & phosphorylase) and irreversible (proteases) covalent modification of enzymes. Mono-cyclic and multi-cyclic cascade systems with specific examples. Feed back inhibition and feed forward stimulation. Allosteric enzymes, qualitative description of "concerted" & "sequential" models for allosteric enzymes. Half site reactivity, positive and negative co-operativity with special reference to aspartate transcarbamoylase and phosphofructokinase. Protein-ligand binding measurement, analysis of binding isotherms, Hill and Scatchard plots.
5. **Multienzyme system –** Occurrence, isolation and their properties: Mechanism of action and regulation of pyruvate dehydrogenase complex. Enzyme-enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase.

BCM 302 : PLANT BIOCHEMISTRY Credits – 4

1. **Electron transport system in plants -** Oxidative phosphorylation, mitochondrial respiratory complexes, order and organization of electron carriers, electrochemical gradient, chemiosmotic theory, ATP synthase and mechanism of ATP synthesis.
2. **Nitrate assimilation** - Structural features of nitrate reductase and nitrite reductase, incorporation of ammonia into organic compounds, regulation of nitrate assimilation.
3. **Photosynthesis –** Photosynthetic apparatus, pigments of photosynthesis, role of carotenoids, photosystems I and II, their location; Hill reaction, photosynthetic electron transport and generation of NADPH & ATP, cyclic and non-cyclic photo-phosphorylations, complexes associated with thylakoid membranes; light harvesting complexes, path of carbon in photosynthesis – C_3 and C_4 pathway of carbon reduction and its regulation, Photorespiration.

4. **Special features of secondary plant metabolism** - Terpenes (classification, biosynthesis), lignin, tannins, pigments, phytochrome, waxes, alkaloids, biosynthesis of nicotine, functions of alkaloids, cell wall components.
5. **Toxins of plant origin –** Mycotoxins, phytohemagglutinins, lathyrogens, nitriles, protease inhibitors, protein toxins.
6. **Stress metabolism in plants -** Environmental stresses, salinity, water stress, heat, chilling, anaerobiosis, pathogenesis, heavy metals, radiations and their impact on plant growth and metabolism, criteria of stress tolerance.
7. **Antioxidative defence system in plants –** Reactive oxygen species and their generation, enzymic and non-enzymic components of antioxidative defense mechanism.

BCM 303: CLINICAL BIOCHEMISTRY Credits – 4

1. **Disorders of Carbohydrate Metabolism -** Diabetes mellitus, glucose and galactose tolerance tests, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, glycogen storage diseases, pentosuria, galactosemia.
2. **Disorders of Lipids –** Plasma lipoproteins, cholesterol, triglycerides and phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher's disease, Tay-Sach's and Niemann-Pick disease, ketone bodies, Abetalipoproteinemia.
3. **Inborn Errors of metabolism –** Phenylketonuria, alkaptonuria, albinism, tyrosinosis, maple syrup urine disease, Lesch-Nyhan syndrome, sickle cell anemia, histidinemia.
4. **Digestive diseases –** Maldigestion, malabsorption, creatorrhoea, diarrhoea and steatorrhoea.
5. **Disorders of liver and kidney –** Jaundice, fatty liver, normal and abnormal functions of liver and kidney. Inulin and urea clearance.
6. **Electrolytes and acid-base balance –** Regulation of electrolyte content of body fluids and maintenance of pH, reabsorption of electrolytes.
7. **Diagnostic Enzymes –** Enzymes in health and diseases. Biochemical diagnosis of diseases by enzyme assays – SGOT, SGPT, CPK, cholinesterase, LDH.
8. **Abnormalities in Nitrogen Metabolism –** Uremia, hyperuricemia, porphyria and factors affecting nitrogen balance.
9. **Blood Clotting –** Disturbances in blood clotting mechanism – hemorrhagic disorders – hemophilia, von Willebrand's disease, purpura, Rendu-Osler-Werber disease, thrombotic thrombocytopenic purpura, disseminated intravascular coagulation, acquired prothrombin complex disorders, circulating anticoagulants.
10. **Cancer –** Cellular differentiation, carcinogens and cancer therapy.

BCM 304M : NEUROBIOCHEMISTRY Credits – 3
(Minor Elective)

1. **Muscle Biochemistry –** Skeletal muscle structure. Actin, myosin, tropomyosin, troponin. Molecular mechanism of contraction. Functional classification of skeletal muscle fibers. Twitch. The motor unit. Role of calmodulin.
2. **Neuromorphology –** Organisation of neuron, dendrites and axons. Glial cells – astrocytes, oligodendrocytes, ependymal cells, Schwan cells. Nerve fiber types and functions.
3. **Neurophysiology** – Generation and conduction of monophasic action potential, saltatory conduction. Synaptic transmission, Neurotransmitters and their action. Blood Brain CSF barrier – Characteristics.
4. **Transport across membranes –** Types of transport (simple diffusion, passive-facilitated diffusion), active transport – primary and secondary group translocation, transport ATPases, transport by vesicle formation.

5. **Neurological disorders –** Headache, facial pain, migraine, epilepsy, multiple sclerosis, Myasthenia Gravis.

BCM 305 : PRACTICAL : ENZYMOLOGY Credits – 3

1. Assay of enzyme activity
2. Isolation and purification of urease.
3. Time course of enzymatic reaction.
4. Influence of substrate concentration on the rate of enzymatic reaction.
5. Effect of pH and temperature on the rate of enzyme reaction.
6. Specificity of enzyme action.
7. Inhibition of enzyme activity. Determination of K_i values.

BCM 306 : PRACTICAL : ENZYME TECHNOLOGY Credits – 3

1. Molecular weight determination of enzyme by gel filtration.
2. Isozyme detection.
3. Immobilization studies:
   a) Preparation of urease entrapped in alginate beads and determination of percent entrapment.
   b) Study of the kinetics of the rate of urea hydrolysis by urease entrapped alginate beads.
   c) Study of reusability and storage stability of urease entrapped alginate beads.
   d) Immobilization of urease by covalent attachment to solid support.

BCM 307: ASSIGNMENT BASED SEMINAR - II Credit – 1

SEMESTER – IV

BCM 401: MOLECULAR BIOLOGY Credits – 4

1. **DNA Replication -** Mechanism of replication, the replicons, origin, primosome and replisomes, properties of prokaryotic and eukaryotic DNA polymerases, synthesis of leading and lagging strands, difference between prokaryotic and eukaryotic replication.
2. **Mechanism of Transcription –** Prokaryotic transcription, promoters, properties of bacterial RNA polymerase; initiation, elongation and termination. Eukaryotic transcription, promoters, enhancers, factors & properties of RNA polymerase I, II, & III. Reverse transcription. Inhibitors of transcription.
3. **Post transcriptional Processing -** Maturation of rRNA, mRNA and tRNA; RNA splicing, introns and exons, consensus sequence function. Poly A tail, 5' capping.
4. **Recombination –** General recombination, site specific recombination and replicative recombination.
5. **Genetic Code –** Deciphering of the codons, reading frame of a sequence, Start/stop codons, degeneracy of the genetic code, Wobble hypothesis, variations to the standard genetic code.
6. **Translation in Pro- and Eukaryotes –** Ribosomes, structure, functional domain and subunit assembly, cell free protein synthesis, direction of protein synthesis (Dintzis experiment), adaptor role of tRNA, formation of initiation complex, chain elongation, translocation & termination, and role of respective factors involved therein. Inhibitors of protein biosynthesis. Comparison of protein biosynthesis in prokaryotes with eukaryotes. Post Translational processing – Proteolytic cleavage, covalent modifications, glycosylation of proteins, disulfide bond formation.
7. **Protein Localization** – Co- and post-translational protein traslocation; chaperones and protein folding, signal sequences, translocons, leader sequences.

8. **Regulation of Transcription and Translation -** Positive and negative control, Repressor & Inducer, concept of operon, lac-, ara-, trp-operons, attenuation, catabolite repression, autogenous regulation, lytic cycle of bacteriophage, stringent response of rRNA synthesis. Hormonal control, transcription factors, steroid receptors. DNA binding motifs in pro- & eukaryotes, helix-turn-helix, zinc fingers, leucine zippers/b zip, helix-loop-helix motifs.

BCM 402: OUTLINES OF BIOTECHNOLOGY Credits – 4

1. **Plant genetic engineering** - Prospects of improving crop productivity, gene isolation, gene transfer systems, T_i plasmid, plant virus vectors, electroporation, microinjection, microprojectile technology, gene expression, regeneration. Application in relation to protein quality, photosynthetic efficacy, nitrogen fixation efficiency and resistance to environmental stresses.
2. **Tissue culture –** Plant tissue culture, anther and pollen culture, protoplast culture, protoplast fusion, embryo rescue, animal cell lines and organ culture.
3. **Transgenic plants and animals** – Advances in producing transgenics, transgenic animals.
4. **Fermentation technology –** Fermentors, general design of fermentor, fermentation processes, production of alcohols, antibiotics, steroids and enzymes; biotransformation, biomass & production of single cell protein.
5. **Hybridoma technology –** Monoclonal antibodies, selection of hybrids, hybridomas, purification and application of monoclonal antibodies.
6. **Xenobiotic metabolism –** Biodegradation, detoxification of xenobiotics by micro-organisms, biodegradation of hydrocarbons, pesticides, surfactants, polyaromatic hydrocarbons, dyes; role of cytochrome P_{450} in detoxification.
7. **Proteomics –** Genome to Proteome, steps and tools for proteome analysis, 2 D-Electrophoresis, BN-PAGE.
8. **Enzyme Technology -** Large scale production of enzymes, enzyme reactors, immobilization of enzymes by chemical and physical methods. Effect of partition on kinetics and on changes in pH and hydrophobicity. Applications: synthetic organic chemistry, industry, food technology, medicines. Synzymes, enzyme electrodes and biosensors. Enzyme Engineering.

BCM 403: PRACTICAL : BIOCHEMICAL PREPARATIONS Credits – 3

1. Fractionation of cell organelles from liver and plant tissues.
2. Isolation of NAD^+ from brewer's yeast.
3. Isolation and estimation of RNA and DNA from yeast, liver, and plants.
4. Extraction, separation and determination of absorption spectra of plant pigments.
5. Isolation and estimation of serum cholesterol.
6. Gel electrophoresis of serum proteins, SDS-PAGE of proteins.

BCM 404: PRACTICAL : CLINICAL BIOCHEMISTRY Credits – 3

1. Determination of α-amylase of saliva.
2. Qualitative and quantitative analysis of following in urine:
   (i) Urea
   (ii) Uric acid
   (iii) Glucose
   (iv) Proteins
   (v) Bence-Jones proteins

(vi) Cl^-, PO_3^{3-}, Ca^{2+}

3. Estimation of hemoglobin by canomethemoglobin
4. Quantification of serum proteins
5. Determination of A/G ratio in serum
6. Estimation of serum glucose, creatinine and uric acid.
7. Assay of serum enzymes : alkaline phosphatase, SGOT, SGPT

BCM 405: ASSIGNMENT BASED SEMINAR - III Credits – 2

BCM 406: PROJECT WORK INCLUDING PRESENTATION COMPRESENSIVE VIVA Credits – 8

M.Sc. BIOTECHNOLOGY
School of Biotechnology
Banaras Hindu University

Semesterwise distribution of Courses and Credits

Semester I		**Number of Credits**
BTM101	Microbiology	4
BTM102	Cell Biology	4
BTM103	Biochemistry & Biophysics	4
BTM104	Genetics and Molecular Biology	4
BTM105	Based on BTM101 & BTM102	3
BTM106	Based on BTM103 & BTM104	3
BTM107M	Microbial Technology (Minor Elective for students of other PG programmes only)	3
	Total	**25**

Semester II:		
BTM201	Biology of the Immune System	4
BTM202	Enzymology & Enzyme Technology	4
BTM203	Genetic Engineering	4
BTM204	Plant Biotechnology	4
BTM205M	Immunobiology (Minor Elective for students of other PG programmes)	3
BTM205	Based on BTM201 & BTM202	3
BTM206	Based on BTM203 & BTM204	3
	Total	**25**

Semester III:		
BTM301	Animal Cell Culture	4
BTM302	Bioprocess Engineering & Technology	4
BTM303	Research Project (Part-I): Based on Research Techniques	6
BTM304	Based on BTM301 & BTM302	3
BTM305	Term Paper based on Review + Seminar	2
BTM306M	Genomics & Proteomics (Minor Elective open to all students)	3
	Total	**22**

Semester IV:		
BTM401	Environmental Biotechnology	4
BTM402	Bioinformatics & Biostatistics	4
BTM403	Research Project (Part II): Dissertation and Seminar	7
BTM404	Based on BTM401 & BTM402	3
	Total	**18**
	Total Credits of 4 Semesters	**90**

Semester I

BTM 101 : Microbiology Credits 4

1. History of Microbiology, Discovery of the microbial world.
2. Isolation, pure culture techniques, Methods of sterilization and Enrichment culture techniques.
3. Bacterial identification, nomenclature and classification, New approaches to bacterial taxonomy / classification including ribotyping and ribosomal RNA sequencing.
4. General structure and features, Brief account of all group of bacteria and cyanobacteria, Rickettsias, Chlamydias and Mycoplasmas,
   Archaea : Archaebacteria and extremophilic microbes – their biotechnological potentials
5. The definition of growth, growth curve, measurement of growth and growth yields, Culture collection and maintenance of cultures.
6. Different modes of nutrition in bacteria, Sulfate reduction, Nitrogen metabolism – nitrate reduction, nitrifying and denitrifying bacteria, Nitrogen fixation and Microbes used as biofertilizer.
7. Viruses : Classification, morphology and composition of viruses in general,
   Plant viruses (TMV, Gemini Virus), Animal viruses (baculoviruses),
   Bacteriophages : Lambda, ϕX 174, cyanophages,
8. Viroids and Prions.

BTM 102 : Cell Biology Credits 4

1. Principles of Microscopy: Optical (including Phase contrast and Differential interference); Fluorescence, Confocal and Electron Microscopy.
2. Structure of Cell (Bacterial, Plant and Animal): Cell membranes, Composition & architecture of Cell Wall,
3. Structure and function of organelles (mitochondria, chloroplast, Nucleus, Golgi apparatus, Lysosomes, Ribosomes) and Cytoskeletal elements.
4. Cell adhesion; cell junctions, cell adhesion molecules & extra-cellular matrix.
5. Basic concepts of signal transduction.
6. Transport across biomembranes: facilitated transport, group translocation, Active transport, Na^+-K^+ ATPase pump.
7. Cell cycle and its control.
8. Oncogenesis.
9. Brief introduction to the biology of following pathogens: AIDS, Malaria, Tuberculosis and Kalajar.
10. Animal cloning and *in vitro* fertilization

BTM103 : Biochemistry & Biophysics Credits 4

1. Carbohydrates; Glycolysis, Gluconeogenesis, Krebs' Cycle, Electron transport chain, Oxidative Phosphorylation.
2. Fatty acids; general properties and ß- oxidation.
3. Nitrogen metabolism: Amino acids (general properties); Amino acid sequencing and composition; end group analysis.
4. Proteins: Protein structure (primary, secondary, tertiary & quartenary), Globular, Fibrous proteins; Ramachandran plot, Circular Dichroism, Hydrophobic and hydrophilic interactions. PAGE, SDS-PAGE, Diagonal Electrophoresis, MALDI.
5. Protein folding (Introduction / Tools to study folding – unfolding phenomenon)
6. DNA - protein interactions; DNA-drug interactions.
7. Photosynthesis; carbon fixation and photorespiration

BTM 104 : Genetics and Molecular Biology Credits 4

1. Introduction to cell division, Mendelian Laws and physical basis of inheritance, dominance and its molecular basis.
2. Basics of gene interaction, cis-trans-test and complementation test, lethal genes, polygenic traits, linkage and gene maps.
3. Double helix: Physico-chemical considerations.
4. Organization of prokaryotic and eukaryotic genomes, supercoiling, repetitive DNA.
5. DNA replication: Mechanism of replication of Prokaryotic & Eukaryotic Chromosome.
6. Mutation: Types and molecular mechanisms of mutations, mutagens, DNA Repair.
7. Transposition: Mechanisms of transposition, role of transposons in mutation.

8. Gene transfer in prokaryotes: Transformation, conjugation, transduction, construction of genetic maps in bacteria.
9. Recombination: Homologous and site - specific recombination.
10. Gene expression in bacteria: Transcription and its regulation; operons, attenuation, anti-termination and anti-sense controls.
11. Prokaryotic translation machinery, mechanism and regulation of translation.
12. Gene expression in eukaryotes: Transcription, general and specific transcription factors, regulatory elements and mechanism of regulation, processing of transcripts.

BTM 105 (Practicals) : **Based on BTM101 & BTM102** **Credits 3**

BTM 106 (Practicals) : **Based on BTM103 & BTM104** **Credits 3**

BTM 107M (Minor Elective) : **Microbial Technology (For students of other PG programs)** **Credits 3**

Semester II

BTM201 : Biology of the Immune System Credits 4

1. Introduction: Innate and acquired immunity, clonal nature of immune response.
2. Nature of antigens.
3. Antibody structure and function.
4. Antigen - antibody reactions and applications.
5. Major histocompatibility complex.
6. Complement system.
7. Hematopoiesis and differentiation.
8. Regulation of the immune response: Activation of B and T-lymphocytes, Cytokines, T-cell regulation, MHC restriction, Immunological tolerance.
9. Cell-mediated cytotoxicity : Mechanism of cytotoxic T cells and NK cells mediated target cell lysis, Antibody dependent cell mediated cytotoxicity, macrophages mediated cytotoxicity.
10. Hypersensitivity.
11. Autoimmunity.
12. Transplantation.
13. Immunity to infection and tumours.

BTM 202 : Enzymology & Enzyme Technology Credits 4

1. Classification and nomenclature of enzymes.
2. Isolation, purification and large-scale production of enzymes.
3. Coenzymes and Cofactors.
4. Steady state kinetics: Methods for estimation of rate of enzyme catalyzed reaction with special reference to Michaelis-Menten equation. Effects of substrate, temperature, pH and inhibitors on enzyme activity and stability.
5. Mechanism of enzyme action (active site, chemical modification) and regulation (Zymogens, Isozymes).
6. Enzyme engineering.
7. Applications of enzymes.
8. Immobilization of Enzymes.

BTM 203 : Genetic Engineering Credits 4

1. Restriction endonucleases, Modification methylases and other enzymes needed in genetic engineering.
2. Cloning vectors: Plasmids and plasmid vectors, Phages and Phage Vectors,
   phagemids, cosmids, artificial chromosome vectors (YAC, BAC), CHEF analysis.
   Animal virus derived vectors - SV40 and retroviral vectors.
3. Molecular cloning: Recombinant DNA techniques, construction of genomic DNA and cDNA libraries, screening of recombinants.
4. Expression strategies for heterologous genes.
5. DNA analysis: labeling of DNA and RNA probes. Southern and fluorescence *in situ* hybridization, DNA fingerprinting, chromosome walking.
6. Techniques for gene expression: Northern and Western blotting, gel retardation technique, DNA footprinting, Primer extension, Sl mapping, Reporter assays.

7. Sequencing of DNA, chemical synthesis of oligonucleotides; techniques of *in vitro* mutagenesis. Site-directed mutagenesis, gene replacement and gene targeting.
8. Polymerase chain reaction and its applications.
9. Use of transposons in genetic analysis: Transposon and T-DNA tagging and its use in identification and isolation of genes.
10. Applications of genetic engineering: Transgenic animals, production of recombinant pharmaceuticals, gene therapy, disease diagnosis.
11. Biosafety regulation: Physical and Biological containment.

BTM 204 : Plant Biotechnology Credits 4

1. Tissue culture media, Initiation and maintenance of callus and suspension cultures; single cell clones.
2. Biochemical production.
3. Totipotency: Organoganesis; somatic embryogenesis; transfer and establishment of whole plants in soil (hardening).
4. Rapid clonal propagation and production of virus -free plants.
5. *In vitro* pollination; embryo culture and embryo rescue.
6. Protoplast fusion, selection of hybrid cells; symmetric and asymmetric hybrids, cybrids.
7. Nuclear cytology of cultured plant cells and somaclonal variations.
8. Production of haploid plants and their utilization.
9. Cryopreservation and slow growth for germ plasm conservation.
10. Gene transfer in nuclear genome and chloroplasts; *Agrobacterium*-mediated gene transfer, direct gene transfer, antibiotic marker-free transgenics.
11. Transgenic plants: insect resistance, virus resistance, abiotic stress tolerance, longer shelf life (including strategies for suppression of endogenous genes), male sterility, enhanced nutrition (golden rice), edible vaccines.
12. Molecular markers: RFLP, RAPD, AFLP, applications of molecular markers

BTM 205 (Practicals) : Based on BTM 201 & BTM 202 Credits 3

BTM 206 (Practicals) : Based on BTM 203 & BTM 204 Credits 4

BTM 205 (Minor Elective) Immunobiology (For students of other PG programs) Credits 3

Semester III

BTM 301 Animal Cell Culture Credits 4

1. Introduction to the balanced salt solutions and simple growth medium. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium.
2. Biology and characterization of the cultured cells.
3. Measuring parameters of growth.
4. Basic techniques of mammalian cell cultures *in vitro*.
5. Serum & protein free defined media and their applications.
6. Measurement of viability and cytotoxicity.
7. Apoptosis
8. Cell synchronization
9. Cell transformation.
10. Applications of animal cell culture: cell culture based products, vaccines, Hybridoma technology and monoclonal antibodies, stem cells and their applications,.
11. Organ, organotypic and histotypic cultures.

BTM 302: Bioprocess Engineering & Technology Credits 4

1. Screening and improvement of industrially important microorganisms.
2. Microbial Growth and Death Kinetics.
3. Media for Industrial Fermentation.
4. Air and Media Sterilization.
5. Types of fermentation processes - Analysis of batch, Fed-batch and continuous bioreactions, stability of microbial reactors, analysis of mixed microbial populations, specialized bioreactors (pulsed, fluidized, photobioreactors etc.,)
6. Measurement and control of bioprocess parameters.

7. Downstream Processing
8. Whole cell Immobilization and their Industrial Applications.
9. Industrial Production of Chemicals - Ethanol, Acids (citric, acetic and gluconic), solvents (glycerol, acetone, butanol), Antibiotics (penicillin, streptomycin, tetracycline), Semisynthetic antibiotics, Amino acids (lysine, glutamic acid), Single Cell Protein.
10. Aeration and agitation: requirement of Oxygen in industrial processes. Concept of volumetric Oxygen transfer coefficient and its determination ($k_L a$). Factors affecting ($k_L a$)
11. Use of microbes in mineral beneficiation and oil recovery.
12. Introduction to Food Technology
    - Elementary Idea of canning and packing.
    - Sterilization and Pastuerization of Food Products.
    - Technology of Typical Food/Food products (bread, cheese, idli).

BTM 303 (Practicals):	**Based on BTM 301 & BTM 302**	**Credits 3**
BTM 304 (Major Elective):	**Research Project (Part I): Based on Research Techniques**	**Credits 6**
BTM 305	**Term Paper Based on Review + Seminar**	**Credits 2**
BTM 306M: (Minor Elective)	**Genomics & Proteomics (Open to all PG students)**	**Credits 3**

Semester IV

BTM 401 Environmental Biotechnology Credits 4

1. Environment: Basic Concepts; Environmental Pollution; Types of Pollution; Measurement of Pollution; Environmental Management
2. Water Pollution and Its Control: Water as a Resource; Water Bodies; Need for Water Management; Sources of Water Pollution; Measurement of Water Pollution
   Waste Water Treatment- Basic Concepts; Physicochemical and biological Treatment Processes, Tertiary Treatment; Disinfection and Disposal
3. Biological Treatment Processes: Biochemistry and Microbiology of Aerobic and Anaerobic Treatment Processes; Suspended and Attached Growth Type Aerobic Processes- Activated Sludge, Oxidation Ditch, Aerated Lagoons, Oxidation Ponds and Their Variations; Trickling Filters, Rotating Biological Contactors, Other Aerobic Processes.
   Suspended and Attached Growth Type Anaerobic Processes- Anaerobic Digesters, Fixed and Fluidized Types of Anaerobic Bioreactors, UASB Bioreactors
   Treatment of Typical Industrial Effluents- Diary, Distillery, Sugar, and Antibiotic Industries
4. Degradation of Xenobiotic Compounds in Environment: Decay Behaviour and Degradative Plasmids; Hydrocarbons; Substituted Hydrocarbons; Oil Pollution; Surfactants; Bioremediation of Contaminated Soils.
5. Biopesticides and biofertilizers; their role in pest and nutrient Management; Wormiculture
6. Solid Wastes: Sources and Management; Composition; Methane Production; Food, Feed and Fuel from Biomass
7. Global Environmental Problems: Ozone Depletion; UV-B and Green House gases and Biotechnological Approaches of their Management

BTM 402: Bioinformatics & Biostatistics Credits 4

1. Introduction to Bioinformatics
2. Searching database and locating genes, Alignment of gene sequences, Local and Global.
3. Analysis of DNA sequence: Finding and calculating core nucleotide sequence, Predicting ORFs, location of transcription start point and end point, getting polypeptide sequence of the extracted core nucleotide sequence, designing primers of specific gene, generation of restriction maps,
4. Generating phylogenetic trees based on DNA sequence and evolutionary relationship
5. Analysis of proteins: Protein classification, homology modeling, trading, prediction of protein structure (secondary and 3 dimensional), tools for structure prediction, validation and visualization.

6. Computer assisted drug design- concept, methods and practical approaches, various computational methods applied to design the drugs: QSAR and 3DQSAR methods, CADD software demonstration
7. Diagrammatic, graphical and tabular representations of data; measures of central tendency, dispersion, skewness and kurtosis.
8. Linear regression, Pearson correlation coefficient and Rank correlation
9. Basic concepts of hypothesis testing, two kinds of error, level significance, p value, t- Test for mean and difference between two means, partial t-test., and Chi square test for goodness of fit.
10. Analysis of variance for one way and two way classified data

BTM 403 (Practicals):	**Based on BTM 401& BTM 402**	**Credits 3**
BTM 404 (Major Elective):	**Research Project (Part II):**	**Credits 7**
	Dissertation and Seminar	

Minor Electives:

BTM 107M: Microbial Technology **Credits 3**

1. Introduction to microbial world. Different groups of microorganisms and their diversity.
2. Industrially important microbes, strain improvement and selection.
3. Isolation and cultivation of microbes and their preservation methods, Growth of microorganisms; batch and continuous culture.
4. Application of microbes in agriculture: PGPB and biofertilizers; microbes as biocontrol agent.
5. Microbes in renewable energy production: Hydrogen, methane and hydrocarbons.
6. Application of microbes in bioremediation of pollutions: Bioremediation of hydrocarbons and xenobiotic compounds, *In situ* and *ex-situ* bioremediation.
7. Commercial exploitation of microbes: Production of recombinant proteins, vaccines and enzymes; microbes as source of industrially important enzymes, immobilized enzymes and their applications.
8. Fermentation processes: batch, Fed-batch and continuous bioreactors, large scale production of antibiotics (penicillin,streptomycin) , ethanol and acetic acid.

BTM 205M: Immunobiology
Credits 3

1. A brief introduction to the history of Immunology, Variolation and vaccination
2. Features of Immune Responses; Primary and Secondary immune responses; Cells and organs of immune system
3. Immunological Recognition (innate, adaptive, antigen presenting cells, Major Histocompatibility Complex)
4. Lymphocytes & Cytokines
5. Phagocytes: Macrophages, Neutrophils, Oxygen-dependent and Oxygen-independent killing mechanisms
6. Lymphocyte functions; Helper T cells, cytotoxic T cells
7. Antigen properties
8. Immunoglobulins: structure & function
9. Complement system
10. Allergies
11. Immunodeficiency & Cancer Immunology

BTM 306M: Genomics and Proteomics **Credits 3**

1. Strategies for genome sequencing: Chain termination method, automated sequencing, pyro-sequencing.
2. Sequence assembly: Clone contig and shotgun approaches.
3. Organization of genomes: main features of bacterial and eukaryotic genome organization.
4. Human genome project and its applications.
5. Locating the genes: ORF scanning, homology searches,
6. Determination of the functions of genes: gene inactivation (knock-out, anti-sense and RNA interference) and gene over expression.
7. Approaches to analyze global gene expression: Transcriptome, Serial Analysis of Gene Expression (SAGE), Expressed Sequence Tags (ESTs), Massively Parallel Signature Sequencing (MPSS), microarray and its applications, gene tagging,
8. Proteome: Methodology to study the proteome, analysis of the functions of proteins, differential display, two hybrid system.

9. Metagenomics: Prospecting for novel genes from metagenomes and their biotechnological applications

M. Sc. BOTANY
Department of Botany
Banaras Hindu University

Semesterwise distribution of Credits and Courses

Semester-I

Course Code	Title	Credits
BOM101	Phycology	3
BOM102	Mycology	3
BOM103	Microbiology	3
BOM104	Angiosperms	3
BOM105	Lab. work based on Course BOM101 & BOM102	4
BOM106	Lab. work based on Course BOM103 & BOM104	4
BOM107M #	*Minor Elective: Biofertilizer Technology (for students of other PG programmes)* *Minor Elective(for Botany students)*	3
	Total	**23**

Semester-II

Course Code	Title	Credits
BOM201	Plant Ecology	3
BOM202	Bryophytes, Pteridophytes and Gymnosperms	3
BOM203	Cytogenetics and Plant Breeding	3
BOM204	Plant Physiology	3
BOM205	Lab. work based on Course BOM201 & BOM202	4
BOM206	Lab. work based on Course BOM203 & BOM204	4
BOM207M	*Minor Elective: Herbal Medicine (for students of other PG programmes and Botany as well)*	3
	Total	**23**

Semester-III

Course Code	Title	Credits
BOM301	Plant Biochemistry and Biotechnology	3
BOM302	Cell and Molecular Biology	3
BOM303	Environmental Management, Computer Application and Biostatistics	3
BOM304	Biochemical and Molecular Techniques, and Bioinformatics	3
BOM305	Lab. work based on Course BOM301 & BOM302	4
BOM306	Lab. work based on Course BOM303 & BOM304	4
BOM307M #	*Minor Elective: Biodiversity and its Conservation (for students of other PG programmes)* *Minor Elective(for Botany students)*	3
	Total	**23**

Semester-IV

Course Code	Title	Credits
BOM401(A-C)	*Major Electives* (any one course out of BOM401A, BOM401B, BOM401C)	3
BOM402(A-C)	*Major Electives* (any one course out of BOM402A, BOM402B, BOM402C)	3
BOM403(A-D)	*Major Electives* (any one course out of BOM403A, BOM403B, BOM403C, BOM403D)	3
BOM404(A-C)	Lab. work based on corresponding courses of BOM401A to BOM401C	2
BOM405(A-C)	Lab. work based on corresponding courses of BOM402A to BOM402C	2
BOM406(A-D)	Lab. work based on corresponding courses of BOM403A to BOM403D	2
BOM407	*Field Study	2
BOM408	Dissertation	4
	Total	**21**
	Grand total	**90**

Major Electives

BOM401A Air Pollution and Climate Change	***BOM402A Conservation and Restoration Ecology***	***BOM403A Applied Phycology***
BOM401B Photobiology and Molecular Biology of Cyanobacteria	***BOM402B Stress Biology and Molecular Genetics of Cyanobacteria***	***BOM403B Environmental and Applied Microbiology***
BOM401C Plant Pathology and Plant Protection	BOM402C Plant Cell and Tissue Culture	BOM403C Water Pollution Management
		BOM403D Microbial Genetics and Biotechnology

Subject to sanction of** leave of absence on duty/duty leave **to the accompanying teachers.
#Botany students shall opt minor elective from other PG programmes.

SEMESTER I

BOM101: Phycology **Credits: 3**

1. Principles, criteria (pigments, flagellation, food reserve and eye spots) and systems of classification
2. Cyanophyta: cell structure, heterocyst and akinete development, chromatic adaptation, thallus organization and reproduction
3. A brief account of thallus organization and reproduction in Chlorophyta, Phaeophyta and Rhodophyta; alternation of generation in Phaeophyta and post -fertilization development and site of meiosis in Rhodophyta
4. A brief account of Xanthophyta, Chrysophyta, Bacillariophyta, Pyrrophyta, Euglenophyta, Eustigmatophyta, Prasinophyta and Prochlorophyta
5. Algae in diverse habitats, algal blooms and Phycoviruses
6. Algae as food, biofertilizers and source of phycocolloids

BOM102: Mycology **Credits: 3**

1. Introduction, scope and general principles of classification of fungi
2. Myxomycotina: Plasmodiophorales
3. Mastigomycotina: Chytridiales, Blastocladiales, Saprolegniales and Peronosporales
4. Zygomycotina:Mucorales and Entomophthorales
5. Ascomycotina: Endomycetales, Protomycetales, Taphrinales, Erysiphales, Eurotiales, Sphaeriales, Helotiales, Phacidiales and Pezizales
6. Basidiomycotina: Uredinales, Ustilaginales, Lycoperdales, Nidulariales, Sclerodermatales, Phallales, Agaricales, Aphyllophorales, Tremellales and Auriculariales
7. Deuteromycotina: Sphaeropsidales, Melanconiales, Moniliales and Mycelia sterilia
8. Lichens: Thallus structure, reproduction and economic importance

BOM103: Microbiology **Credits: 3**

1. Introduction: A brief idea of microbial diversity; present status and future challenges; a general account of Archaea
2. Nutritional types of microorganisms, *Rhizobium*-legume symbiosis and mycorrhiza
3. Anoxygenic photosynthesis with special reference to light reaction in purple bacteria; methanogenesis
4. Genetics of bacteria: Genetic recombination- an overview; mechanisms of transformation, conjugation and transduction in bacteria; role of microorganisms in genetic engineering
5. Lytic cycle in T even phages and its regulation; lysogeny and its regulation in lambda phage; a brief account of viroids and prions
6. Water-borne pathogenic microbes; role of microbes in wastewater treatment with special reference to activated sludge
7. Basic design of a fermentor; biosensors; bioremediation of hydrocarbon and metal polluted waters

BOM104: Angiosperms **Credits: 3**

1. Systematics: Outline of classification of Angiosperms; Hutchinson, Takhtajan, Cronquist, merits and demerits
2. Botanical nomenclature: International code of Botanic Nomenclature; principles: Rules and recommendations; priority; typification; Rules of effective and valid publications; retention and choice of names
3. Taxonomic featues, systematic phylogeny and economic importance of families**:** Magnoliaceae, Capparidaceae, Combretaceae, Rosaceae**,** Asteraceae, Apocynaceae, Asclepiadaceae, Convolvulaceae, Scrophulariaceae, Acanthaceae, Bignoniaceae, Lamiaceae, Verbenaceae, Polygonaceae, Euphorbiaceae, Orchidacae, Zingiberaceae, Araceae, Cyperaceae and Poaceae
4. Numerical taxonomy: Aims and objectives, characters and attributes, OTUs, coding, cluster analysis, merits and demerits
5. Chemotaxonomy**:** Role of phytochemicals (non-protein amino acids, alkaloids, betalins, cynogenic glucosides, silica, gypsum, raphides, glucosinolate, flavonoids, terpenoids) in taxonomy
6. Biosystematics: concepts; biosystematic categories; methods in experimental taxonomy
7. Embryology in relation to taxonomy
8. Molecular approaches to plant taxonomy: Application of DNA markers in angiosperm taxonomy; molecular phylogeny
9. Self incompatibility: Structural and biochemical aspects; methods to overcome incompatibility - mixed pollination, bud pollination; intra -ovarian pollination, *in vitro* pollination
10. Experimental embryology: Haploid production; diploidization of haploids, importance of haploids; embyro culture; culture of differentiated and mature embryos; role of natural plant extracts and growth hormones; embryo-nurse endosperm transplantation; culturing of embryonal segments; practical aspects of embryo culture

BOM105: Lab. work based on Course BOM101 & BOM102 **Credits: 4**

BOM106: Lab. work based on Course BOM103 & BOM104 **Credits: 4**

BOM107M: Biofertilizer Technology **Credits: 3**

1. Biofertilizers: Definition and types, importance of biofertlizers in agriculture
2. Characteristics of biofertilizers: *Rhizobium, Azotobactor, Azospirillum*, Phosphate-solubilizing microorganisms, cyanobacteria, *Azolla,* Mycorrhizae
3. Symbiosis: Physiology, biochemistry and molecular genetics of symbiosis
4. Enzymes and their regulation: Nitrogenase, hydrogenase
5. Production technology: Strain selection, sterilization, growth and fermentation, mass production of various biofertilizers
6. Application technology: Standards and quality control, application for field and tree crops, nursery plants and seedlings
7. Extension, promotion and marketing: Extension strategies, diagnosis for the effectiveness of inoculation, improvement in distribution system

SEMESTER II

BOM201: Plant Ecology **Credits: 3**

1. Population concepts: Characteristics, dynamics and control
2. Vegetation organization and characteristics: Concepts of community and continuum; community coefficients, interspecific associations, ordination; ecological niche; species diversity (α, β, γ)
3. Ecological succession: Models and mechanisms of ecological succession; changes in ecosystem properties during succession
4. Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies); decomposition (mechanism, controlling factors); ecosystem nutrient cycles
5. Ecosystem stability: Concept (resistance and resilience); ecological perturbations (natural and anthropogenic) and their impact on plants and ecosystems; ecology of plant invasion
6. Biological diversity: Concept and levels; distribution and global patterns; terrestrial biodiversity hot spots; role of biodiversity in ecosystem functions; IUCN categories of threat; inventory; conservation, protected area network

7. Environmental pollution: Kinds, sources, effects on plants and ecosystems
8. Global change: Greenhouse gases, consequences of climate change; ozone layer depletion, causes and consequences

BOM202: Bryophytes, Pteridophytes and Gymnosperms Credits: 3

Bryophytes:

1. Classification of Bryophytes
2. Comparative account of gametophyte structure
3. Sporophytic structure and evolution; Peristome structure and its significance in the classification of Mosses
4. Economic importance of Bryophytes

Pteridophytes:

1. Classification of Pteridophytes
2. Early vascular plants: Rhyniophyta, Trimerophytophyta and Zosterophylophyta
3. Brief account of the range of structure and reproduction in Ferns
4. Telome concept, apogamy and apospory, heterospory and seed habit
5. Economic importance of Pteridophytes

Gymnosperms:

1. Classification of Gymnosperms
2. Kinds of fossils, process of fossilization
3. General account of Glossopteridaceae
4. Comparative study of Coniferales (Pinaceae, Cupressaceae, Araucariaceae, Podocarpaceae, Cephalotaxaceae, Taxodiaceae), Taxales and Gnetales (Gnetaceae, Ephedraceae and Welwitschiaceae)
5. Economic importance of Gymnosperms

BOM203: Cytogenetics and Plant Breeding Credits: 3

1. Chromatin organization and replication: Chemical constituents- DNA and histones, nucleosome and higher order organization, DNA packaging and genetic activity, nucleosome assembly and deassembly
2. Cytogenetics of haploids: Haploidy/monopolidy, meiosis and breeding behaviour of haploids, uses of haploids in plant breeding and genetic studies
3. Aneu- and euploids: Induction and characterization of monosomics, trisomics and nullisomics, aneupolid gene mapping, inheritance pattern in autopolyploids, status of allopolyploids in plant evolution
4. Chromosome banding patterns: Linear differentiation of chromosome segments, types of chromosome banding, uses of chromosome banding in cytogenetics
5. Organization of eukaryotic genetic material: Nuclear DNA and C-value paradox, DNA content and adaptability, repetitive DNA, split genes, overlapping genes
6. Plant breeding and crop improvement: Objectives and scope of plant breeding, hybridization in self- and cross-pollinated crops, genetic basis of inbreeding depression and heterosis, breeding for disease and insect resistance, transgenes and transgenic plants
7. Alien gene transfer through chromosome: Transfer of gene through individual chromosome, characterization and utility of alien addition and substitution lines
8. Physical and genetic mapping using molecular markers

BOM204: Plant Physiology Credits: 3

1. Water relations: Properties of water, water in tissues and cells, measurement of cellular water
2. Transport of water and solutes: Uptake of water, comparison of xylem and phloem transports, phloem loading and unloading, passive and active transports, soil-plant-atmosphere continuum
3. Photosynthesis: Basic principles of light absorption, excitation energy transfer, electron transport, proton electrochemical potential, evolution of photosynthetic processes, photosynthetic quantum yield and energy conversion efficiency and photorespiration

4. Physiological responses to abiotic stresses: Light, temperature, water and salts; acclimation of physiological processes under abiotic stresses
5. Sensory photobiology: History, discovery of phytochromes and cryptochromes and their photochemical and biochemical properties, photophysiology of light induced repsonses Cellular localisation, molecular mechanism of action of photomorphogenetic receptors, signalling and gene expression
6. Plant growth regulators: Physiological effects and mechanism of action of plant growth hormones, hormone receptors, signal transduction and gene expression
7. The flowering process: Photoperiodism and its significance, endogenous clock and its regulation, floral induction and development

BOM205: Lab. work based on Course BOM201 & BOM202 **Credits: 4**

BOM206: Lab. work based on Course BOM203 & BOM204 **Credits: 4**

BOM207M: Herbal Medicine **Credits: 3**

1. Medicinal plant research scenario in India
2. Diagnostic features, bioactive molecules and therapeutic value of some common medicinal plants
3. Standardisation of herbal drugs
4. Commercial cultivation of medicinal plants
5. Conservation of medicinal plants
6. Neutraceuticals and medicinal food
7. Bioprospecting, biopiracy and protection of traditional medicinal knowledge (IPR)

SEMESTER III

BOM301: Plant Biochemistry and Biotechnology **Credits: 3**

1. Energetics of metabolic processes: Energy rich phosphate compounds, electron transport and phosphorylation, β -oxidation of lipids
2. Enzymology: General aspects, prosthetic groups and coenzymes, mechanism of catalysis, kinetics, Michaelis-Menten equation, bisubstrate reactions, active sites, factors contributing to the catalytic efficiency, enzyme inhibition, regulatory enzymes, ribozymes
3. Biological nitrogen fixation: Nitrogenase enzyme, substrates for nitrogenase, reaction mechanism, strategies to exclude oxygen and need to control hydrogen evolution
4. Inorganic nitrogen and sulphur metabolism: Introduction, nitrate transport, nitrate and nitrite reductase, inhibitors of nitrate and nitrite reductases, localization and regulation of nitrate and nitrite reductases, sulphate uptake, activation and transfer, assimilatory pathways of sulphate reduction
5. Biosynthesis of proteins: Transcription and translation, regulation of protein and enzyme synthesis (*lac operon*)
6. Plant cell and tissue culture: Concept of cellular differentiation and totipotency, clonal propagation, artificial seeds, somaclones, production of secondary metabolites/natural products, cryopreservation and germplasm storage
7. Recombinant DNA technology: Gene transfer
8. Basic concept of genomics and proteomics

BOM302: Cell and Molecular Biology **Credits: 3**

1. Cell: Concept, structural organization of plant cell
2. Mitochondria: Structure, genome organization, protein import and mitochondrial assembly
3. Chloroplast: Structure, genome organization, import and sorting of chloroplast proteins
4. Endoplasmic reticulum: Structure, translocation of secretory proteins across ER membrane, insertion of protein into ER membrane, protein folding and processing
5. Golgi apparatus: Organization, protein glycosylation, protein sorting and export from Golgi, the vesicular transport mechanism
6. Nucleus: Nuclear envelope, nuclear pore complex, trafficking between nucleus and cytoplasm

7. Gene and genome: Fine structure of gene, genome organization
8. DNA/gene manipulating enzymes: Endonuclease, exonulcease, ligase, polymerase, phosphatase, transcriptase, transferase, topoisomerase
9. DNA replication: Various models, speed of replication, collaboration of proteins, process and termination of replication
10. DNA damage and repair: Thymine dimer, 6-4 photoproducts, photoreactivation, excision repair
11. Genetic recombination: Holliday, Potter & Dressler, Meselson and Radding and Szostak model of genetic recombination
12. Gene cloning: Cloning vectors, molecular cloning and construction of DNA libraries
13. Mobile genetic elements: Insertion elements, transposons

BOM303: Environmental Management, Computer Application and Biostatistics Credits: 3

Environmental Management

1. Introduction and scope of environmental management
2. Basic concepts of sustainable development
3. Environmental impact assessment (EIA), general guidelines for the preparation of environmental impact statement
4. Scope and types of environmental audit, energy audit, cost benefit analysis
5. Environmental management plan, ISO 14000 standards and certification
6. Environmental risk management and environmental safety norms
7. International summits and treaties related with environment

Computer Application

1. Basic concepts of computer hardware
2. Operating systems-Windows, Unix and Linux
3. Use of common application software in biology: word processing, spreadsheets, graphics and database
4. Introduction to web browsing software and search engines with special reference to online bioscience resources

Biostatistics

1. General concepts and terminology
2. Sampling methods
3. Measures of location, scale and shape
4. Contingency tables and chi-square test
5. Comparison of means: t-test, multiple range tests
6. Simple experimental design and analysis of variance
7. Correlation and regression analysis
8. Introduction to multivariate methods

BOM304: Biochemical and Molecular Techniques, and Bioinformatics Credits: 3

1. Electrophoresis: Polyacrylamide gel electrophoresis (PAGE), agarose gel electrophoresis, native PAGE, SDS-PAGE, 2D electrophoresis, mass spectrometry
2. Isolation and purification: Genomic and plasmid DNA; RNA; proteins
3. Isoelectric focusing (IEF): Principles, kinds of pH gradients used in IEF- free carrier ampholytes, immobilized pH gradients
4. Blotting: Principles, types of blotting, immunoblotting - Southern, Northern, Western and Dot blots
5. DNA amplification and genome mapping: PCR, RT-PCR, RFLPs, RAPD, FISH
6. Genome expression analysis: Microarray, EST, SAGE
7. DNA sequencing: Various methods of DNA sequencing
8. Gene silencing: RNA interference (RNAi)
9. Chromatography: Gel filtration, ion exchange & affinity chromatography, TLC, HPLC, GC- basic concept
10. Spectroscopy: basic concept, NMR & ESR spectroscopy
11. Microscopy: Phase contrast, confocal, fluorescence, scanning & transmission electron microscopy
12. Bioinformatics: Database, sequence analysis, phylogenetic inference package, sites and centres

BOM305: Lab. work based on Course BOM301 & BOM302 **Credits: 4**

BOM306: Lab. work based on Course BOM303 & BOM304 **Credits: 4**

BOM307M: Biodiversity and its Conservation **Credits: 3**

1. Introduction to biodiversity
2. Levels of biodiversity: Genetic, species, community and ecosystem
3. Magnitude and distribution: Diversity gradients and related hypotheses, methods for biodiversity monitoring, megadiversity zones and hot spots
4. Biodiversity and ecosystem functions: Concepts and models
5. Biodiversity and ecosystem services: Provisioning, regulating, supporting and cultural
6. Threats to biodiversity: Causes of biodiversity loss, species extinction, vulnerability of species to extinction, IUCN threat categories, Red data book
7. Strategies for biodiversity conservation: Principles of biodiversity conservation, in-situ and ex-situ conservation strategies; Biodiversity act

SEMESTER IV

BOM401A: Air Pollution and Climate Change **Credits: 3**

1. Atmospheric composition and climate; Gaseous and particulate pollutants, emission trends and scenarios; climate change, drivers of climate change, greenhouse gas emission scenarios; indoor air pollution
2. Sulphur derivatives: Sources and cycling of sulphur, effects on plants, human health and ecosystems, mechanism of toxicity, resistance and buffering, sulphur metabolism, threshold and injury
3. Nitrogen derivatives: Formation and sources; deposition, uptake, metabolism, critical load; effects on plants, human health and ecosystems
4. Fluoride derivatives: Sources and cycling, bioaccumulation, threshold and injury; effects on plants, human health and ecosystems
5. Oxidants: Formation and sources, photochemical smog; effects on plants and human health, mechanism of toxicity, resistance, critical load
6. Stratospheric ozone depletion: Phenomenon, causes, irradiation scenarios; effects of enhanced UV-B on plants, microbes and human health, biological action spectra
7. Greenhouse effects: Process; consequences, global warming, sea level rise, albedo, oceanic influences, agriculture, natural vegetation; effects of increased CO_2 on plants; human implications
8. Acid rain: Formation, dispersion and deposition, trends; consequences on soil fertility, rivers and lakes; effects on plants, leaf injury, buffering, reproduction; forest decline; effects on fisheries
9. Biomonitoring of air pollution: Concept, active and passive monitoring; bioindicator parameters; air pollution tolerance indices; control of air pollution by plants, green belt design

BOM401B: Photobiology and Molecular Biology of Cyanobacteria Credits: 3

1. Molecular aspects of cyanobacterial nitrogen fixation: Genetic structure of the N_2 fixation system, molecular mechanisms of heterocyst differentiation and metabolism, genetic aspects of nitate, nitrite and ammonia assimilation
2. Accessory light harvesting complex: Phycobilisomes, phycobiliproteins, linker polypeptides, energy transfer, gene organization, chromatic adaptation and gene expression
3. Photobiology: Photobiological and molecular aspects of UV-induced damage and repair in cyanobacteria
4. Molecular mechanisms of photoprotection: Mycosporine-like amino acids (MAAs), scytonemin
5. Cyanobacterial toxins: Types of cyanobacterial toxin, molecular tools for the identification of toxic cyanobacteria, biochemical and molecular aspects of toxin production, ecological implications
6. Basic strategies for the generation of transgenic cyanobacteria

BOM401C: Plant Pathology and Plant Protection **Credits: 3**

1. Historical and developmental aspects of plant pathology
2. Mode of infection and role of enzymes and toxins in plant disease

3. Defense mechanisms of plants against infection: Preexisting structural and chemical defense, induced structural and chemical defense, hypersensitive reaction, role of phytoalexins and other phenolic compounds
4. Management of plant diseases: Cultural, chemical, biological, biopesticides, breeding for resistant varieties, plant quarantine,integrated pest management
5. Post-harvest pathology: Fungal deterioration of food commodities, mycotoxins and health hazards, control measures
6. Molecular plant pathology: Molecular aspects of host pathogen interactions - PR proteins, degradation of phytoalexins, systemic resistance mechanism; application of molecular biology to plant disease control - transgenic approach for crop protection, engineering chemicals that elicit defense response to plants
7. Study of plant diseases caused by fungi, bacteria, viruses, nematodes and mycoplasma like organisms: Wart disease of potato, blight of colocasia, downy mildew of cucurbits, stem gall of coriander, peach leaf curl, ergot of bajra, smut of sugarcane, Karnal bunt of wheat, linseed rust, Tikka disease of groundnut, red rot of sugarcane, Panama disease (*Fusarium* wilt) of banana, bacterial blight of rice, leaf curl of tomato, yellow vein mosaic of bhindi, mosaic of sugarcane, potato spindle tuber mosaic, ear cockles of wheat, grassy shoot of sugarcane, phylloidy of sesamum, Citrus greening

BOM402A: Conservation and Restoration Ecology **Credits: 3**

1. Introduction to Conservation Ecology: Principles, postulates and ethics
2. Population dynamics and conservation: Genetic variation and its loss, variation in natural populations, mechanisms of population regulation, habitat specific demography, population viability analysis
3. Species and habitat conservation: Prioritizing species and habitat, protected area networks, theory of reserve design
4. Diagnosis and prediction: Predicting ecological consequences of changes, environmental impact assessment
5. Conservation strategies: Planning and management, plan process for species and site management; general principles of management; models of sustainable development
6. Ecology of disturbed ecosystems: Ecosystem dynamics and stability, disturbances, impact of disturbances on the structure and functioning of ecosystems
7. Aims and strategies of restoration: Concepts of restoration, ecosystem reconstruction, major tools used in restoration
8. Restoration of biological diversity: Acceleration of ecological succession, reintroduction of biota
9. Degradation and restoration of natural ecosystems: Forest, grassland and lake
10. Restoration of degraded soils: Saline/sodic soils, contaminated soils, mine spoils

BOM402B: Stress Biology and Molecular Genetics of Cyanobacteria **Credits: 3**

1. Stress environment: Abiotic factors (Water, temperature, light, pH, salinity and nutrient concentration); Stress habitats (physico-chemical characterization, species diversity and population dynamics)
2. Stress damages: Cell structure, proteins, nucleic acids, lipids and membranes, physiological process, protein synthesis
3. Mechanism of adaptations: Role of carbohydrates, proteins, nucleic acids and lipids, pigment-involvements, signal transduction
4. Genome organization of model cyanobacteria *Synechocystis* sp. PCC 6803, *Anabaena* sp. PCC 7120, plasmids, use of bioinformatics in nucleic acid sequence database, brief knowledge of sequence alignment and its significance
5. Mode of gene transfer in cyanobacteria with special reference to conjugation, transformation, electroporation, spontaneous and induced mutagenesis, transposon mutagenesis, expression of foreign gene(s) in cyanobacteria and its consequences
6. Cyanobacteria in human welfare: Production of fine chemicals, polysaccharides, bioactive molecules, pigments, antioxidants, lipids and polyunsaturated fatty acids, biofertilizer and hydrogen

BOM402C: Plant Cell and Tissue Culture **Credits: 3**

1. Historical perspectives

2. Principles of plant tissue culture: Organization of laboratory, media composition and preparation, aseptic manipulation
3. Cell culture and cell cloning
4. Cellular totipotency: Process and mechanism
5. Somatic embryogenesis: Induction and controlling factors
6. Organogenesis: Process and controlling factors
7. Haploids: Androgenic and gynogenic; obtention and promises
8. Somatic hybridization: Isolation, culture and fusion of protoplasts: regeneration of hybrids and cybrids
9. Clonal propagation: Micropropagation
10. Somaclonal and gametoclonal variation and their selection
11. Transgenic plants: Method of transformation, selection, identification, molecular analysis for confirmation and application
12. Germplasm conservation and synthetic seed technology
13. Industrial application: Suspension culture, hairy root culture and bioreactors

BOM403A: Applied Phycology **Credits: 3**

1. Models (Monod and Droop) of nutrient-regulated phytoplankton growth; common methods for mass cultivation of microalgae
2. Causal factors and dynamics of freshwater and marine algal blooms; physical and chemical means and bio-manipulation (top-down and bottom-up) for controlling nuisance blooms
3. Consequences of blooms including toxins of cyanobacteria and dinoflagellates; algal biofouling of ships and its control
4. Commercial potential of *Spirulina, Dunaliella* and *Porphyra*; hydrogen production by algae
5. High-rate algal ponds for the treatment of wastewaters and for the production of useful biomass and energy; immobilized and inactivated algal biomass for metal and nutrient removal
6. A brief account of cyanobacterial genomics and proteomics
7. Paddy field cyanobacteria: Qualitative and quantitative assessment of their biodiversity using molecular tools; their use as biofertilizer, reclamation of usar lands
8. Influence of salt, heavy metals and acid rain on algae: Physiological and biochemical effects; biochemical and molecular mechanisms of tolerance
9. Bioassays and field assessment of pollutant effects; single and multispecies laboratory bioassays; taxonomic and non-taxonomic approaches for the assessment of pollutant effects in nature

BOM403B: Environmental and Applied Microbiology **Credits: 3**

1. Microbes as tools for understanding the biological processes: Physiology, biochemistry, genetics, molecular biology, genomics, proteomics
2. Microbes and environment: Pollution abatement, bioindicators, restoration of degraded ecosystems, biodegradation, bioremediation, biogenic gases, microbes in biological warfare
3. Application of microbes in fermentation processes: Types, design and maintenance of bioreactors, application of fermentation technology in industry
4. Medical microbiology: Microbes as causal agents of human and animal diseases; immunology: basic concepts, vaccines, immunotherapy
5. Role of microbes in relation to agriculture: Nitrogen economy, plant health, biological control
6. Symbiotic associations: Concepts, types and applications
7. Microbes in food and dairy industry: Mushrooms, fermented foods, microbial spoilage of food and dairy products, toxins
8. Extremophiles and their biotechnological applications
9. Microbial technology: Biosensors, biomolecules, enzymes

BOM403C: Water Pollution Management **Credits: 3**

1. Freshwater: Classification of water bodies; physico-chemical and biological properties of freshwater; water quality at euphotic and profundal zones; drinking, bathing and irrigational water quality standards
2. Water pollution sources: Major sources of water pollution; Physico-chemical and biological properties of sewage; quality of industrial effluents produced from textile, dairy, leather, thermal power and chemical industries

3. Effect on water quality: Changes in water quality due to discharge of city sewage; industrial effluents; effects on phytoplankton productivity; bio-indicators of water pollution
4. Domestic wastewater treatment: Various stages of treatment of sewage with special reference to advanced wastewater treatments; biological treatment of wastewater
5. Industrial wastewater treatment: Treatment of industrial effluents released from textile, dairy, leather, thermal power and chemical industries
6. Disinfection of treated water: Ozonization of secondary treated wastewater; chemical and other methods for disinfection
7. Water management strategies: Rain water harvesting, use of rain water, recharging of ground water; use of domestic waste water; recycling of waste water; recycling of industrial effluents after treatment
8. Water pollution monitoring and management bodies: Important organizations involved in water pollution monitoring in India and role of NGOs in water pollution management

BOM403D: Microbial Genetics and Biotechnology **Credits: 3**

1. Tools of microbial genetics: Bacteriophages (T_4, lambda, Mu), *Neurosopra crassa*
2. Mutation: Spontaneous and induced mutation, mutagens and their effects on DNA structure and protein synthesis
3. Genetic recombination: Homologous recombination, site specific recombination and transposition
4. Regulation of genome activity: Signal transmission, changes in genome activity, regulation of genome activity during development
5. Gene expression and regulation: Lactose and Tryptophan operon, Regulation of virulence genes in pathogenic bacteria, heat shock regulon, SOS regulon and Cps regulon
6. Cell signalling: Communication between cell and environment with special reference to nutrients (N and P) and temperature
7. Bacterial associations in plants: perception and signalling
8. Microbial toxins: Types, biochemical and molecular basis of toxins production, mode of action
9. Gene manipulation for production of novel commercial products: biopolymers and antibiotics

BOM404(A-C) Lab. work based on corresponding courses of BOM401A to BOM401C **Credits: 2**

BOM405(A-C) Lab. work based on corresponding courses of BOM402A to BOM402C **Credits: 2**

BOM406(A-D) Lab. work based on corresponding courses of BOM403A to BOM403D **Credits: 2**

BOM407: Field Study **Credits: 2**

BOM408: Dissertation **Credits: 4**

M.Sc. CHEMISTRY
Department of Chemistry
Banaras Hindu University

Semesterwise distribution of Courses and Credits

Semester -I

Course Code	*Title*	Credits
CHM101	Analytical Chemistry I	3
CHM102	Inorganic Chemistry I	3
CHM103	Organic Chemistry I	3
CHM104	Physical Chemistry I	3
CHM105	Inorganic Chemistry Practical	2
CHM106	Organic Chemistry Practical	2
CHM107	Physical Chemistry Practical	2
CHM108M	Polymer Chemistry (Minor Elective, for students of Chemistry and other PG programmes)	3
	Total:	21
	Semester-II	
CHM201	Analytical Chemistry II	3
CHM202	Inorganic Chemistry II	3
CHM203	Organic Chemistry II	3
CHM204	Physical Chemistry II	3
CHM205	Chemical Binding	3
CHM206	Inorganic Chemistry Practical	2
CHM207	Organic Chemistry Practical	2
CHM208	Physical Chemistry Practical	2
CHM209M #	Organic Chemistry - Applied Aspects Only (Minor Elective for students of other PG programmes)	3
	Total :	**24**
	Semester-III	
CHM301	Molecular Spectroscopy (Core Paper)	3
CHM302	Biological Chemistry (Core Paper)	3
CHM303	Specialization Paper-I (A/I/O/P)*	3
CHM304	Specialization Paper-II (A/I/O/P)*	3
CHM305	Practical (A/I/O/P)*	6
CHM306-309	Elective Paper I (Any one out of the four paperss)$^{+}$	3
#	Minor Elective III (from other PG programmes)	3
	Total :	**24**
	Semester-IV	
CHM401	Computer Applications in Chemistry (core paper)	2
CHM402	Specialization Paper-III (A/I/O/P)*	3
CHM403	Specialization Paper-IV (A/I/O/P)*	3
CHM404	Specialization Paper-V (A/I/O/P)*	3
CHM405	Project	5
CHM406-409	Elective Paper II (Any one of the four papers) $^{++}$	3
CHM410	Laboratory work for Computer Applications in Chemistry (Common to all branches)	2
	Total:	**21**
	Total :	**90**

A-Analytical Chemistry **I- I**norganic Chemistry **O-O**rganic Chemistry **P-P**hysical Chemistry

Elective Papers

$^{+}$Elective - I

CHM306	Forensic Analysis
CHM307	Chemical Applications of Group Theory
CHM308	Medicinal Chemistry
CHM309	Physical Methods in Chemistry

$^{++}$Elective - II

CHM406	Environmental Chemistry
CHM407	Photo Inorganic Chemistry
CHM408	Bioorganic Chemistry
CHM409	Materials Chemistry

Minor Electives

To be offered by chemistry students from other PG programmes

* Details of specialization courses are as follows

* Details of Specialization Papers

Semester - III

		Credits
	Specialization Papers - I & II	
	Analytical Chemistry	
CHM303 (A):	Principles of Analytical Chemistry	3
CHM304 (A):	Microanalytical Techniques	3
	Inorganic Chemistry	
CHM303 (I):	Organometallic Chemistry of Transition Metals	3
CHM304 (I):	Bio-inorganic Chemistry	3
	Organic Chemistry	
CHM303 (O):	Stereochemistry and Photochemistry	3
CHM304 (O):	Natural Products	3
	Physical Chemistry	
CHM303 (P):	Electrochemistry	3
CHM304 (P):	Quantum Chemistry	3
	CHM305 Practical	
CHM305 (A):	Analytical Chemistry Practical	6
CHM305 (I):	Inorganic Chemistry Practical	6
CHM305 (O):	Organic Chemistry Practical	6
CHM305 (P):	Physical Chemistry Practical	6

Semester - IV

Specialization Papers – III, IV, V

	Analytical Chemistry	
CHM402 (A):	Separation Techniques	3
CHM403 (A):	Electroanalytical Methods	3
CHM404 (A):	Spectrochemical Analysis	3
	Inorganic Chemistry	
CHM402 (I):	Structural Methods in Inorganic Chemistry	3
CHM403 (I):	Inorganic Rings, Chains, and Clusters	3
CHM404 (I):	Special Topics in Inorganic Chemistry	3
	Organic Chemistry	
CHM402 (O):	Application of Spectroscopy to Structural Analysis	3
CHM403 (O):	Reagents and Organic Synthesis	3
CHM404 (O):	Heterocycles and Vitamins	3
	Physical Chemistry	
CHM402 (P):	Statistical Mechanics	3
CHM403 (P):	Solid State Chemistry	3
CHM404 (P):	Chemical Kinetics	3
	CHM405: Project	
CHM405 (A):	Analytical Chemistry	5
CHM405 (I):	Inorganic Chemistry	5
CHM405 (O):	Organic Chemistry	5
CHM405 (P):	Physical Chemistry	5

Semester- I

CHM101: Analytical Chemistry-I

Credits: 3

1. ***Introduction****:* Scope & objectives, Analytical chemistry and chemical analysis, Classification of analytical methods, Method selection, Sample processing, Steps in a quantitative analysis, Quantitative range (bispartite classification), Data organisation, Analytical validations, Limit of detection and limit of quantitation, The tools of analytical chemistry and good lab practices.

2. ***Analytical chemometrics:*** Propagation of measurement uncertainties (inaccuracy and imprecision). Useful statistical test: test of significance, the F test, the student 't' test, the chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, significant figures, regression analysis (least square method for linear and non-linear plots), statistics of sampling and detection limit evaluation. Chemometrics for optimization, modeling and parameter estimation, factor analysis, resolution and pattern recognition.

3. ***Treatment of Equilibria****:* Solvents and solutions, general treatment of equilibria in aqueous medium involving monoprotic weak acid and weak base, and salts of weak acids and weak bases. Activity and concentration, Effect of electrolytes on chemical equilibria, Calculation of pH, Constructing titration curves from charge balance and mass balance equations, Acid-base titrations and theory of pH indicators, Complexation equilibria and complexometric titrations, Redox equilibria and redox titration, Theory of redox indicators, Precipitation reaction and precipitation titrations and theory of adsorption indicators.

4. ***Spectrophotometric Determination of Stoichiometry of Complexes****:* Job's method of continuous variation, mole ratio and slope ratio analysis, Advantages and limitations, typical examples

5. ***Automation in the Laboratory****:* Principles of automation, Process control through automated instruments, Autoanalyzers (single channel and multi-channel), Basic sequences of multi-fold operational analyzers in segmented and non-segmented flows.

Books Recommended

1. R. L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, *Modern Methods of Chemical Analysis*, 2nd Edition (1976), John Wiley, New York.
2. G. D. Christian, *Analytical Chemistry*, 5th Edition (1994), John Wiley & Sons, New York.
3. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Analytical Chemistry - An Introduction*, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
4. J. H. Kennedy, *Analytical Chemistry: Principles*, 2nd Edition (1990), Saunders Holt, London.

CHM102: Inorganic Chemistry-I

Credits:3

1. **Metal-Ligand Bonding in Transition Metal Complexes:** Crystal field splitting diagrams in complexes of low symmetry; Spectrochemical and Nephelauxetic series; thermodynamic and structural effects; site selection in spinels, Jahn-Teller distortions; experimental evidence for metal-ligand orbital overlap; ligand field theory, molecular orbital theory as applied to metal complexes, brief introduction to Angular Overlap Model.

2. **Electronic spectra of Transition Metal Complexes:** Spectroscopic ground states; Orgel energy level and Tanabe-Sugano diagrams for transition metal complexes; Charge transfer spectra; electronic spectra of octahedral and tetrahedral Co(II) and Ni(II) complexes and calculation of ligand-field parameters.

3. Symmetry based concepts of energy level diagrams of metal complexes.

Books Recommended

1. F.A. Cotton and G. Wilkinson *Advanced Inorganic Chemistry*, 6th Edn. (1999), John Wiley & Sons, New York.
2. James E. Huheey, *Inorganic Chemistry*, 4th Edn. (1993), Addison-Wesley Pub. Co., New York.
3. R. S. Drago, *Physical Methods in Inorganic Chemistry*, International Edn. (1971), Affiliated East-West Press, New Delhi.
4. Keith F. Purcell and John C. Kotz, *Inorganic Chemistry,* W. B. Sauders Com. (1987), Hong Kong.
5. K. Veera Reddy, *Symmetry and Spectroscopy of Molecules*, New Age International Pvt. Ltd., New Delhi (1999).
6. B.N. Figgis, *Introduction to Ligand Fields,* Wiley Eastern Ltd. New Delhi (1976).

CHM103: Organic Chemistry-I

Credits:3

1. ***Aromaticity:*** *Benzenoid and nonbenzenoid systems, antiaromaticity, homoaromaticity, alternant and non-alternant hydrocarbons.*

2. ***Effects of Structure on Reactivity****: Linear free energy relationships (LFER), the Hammett equation – substituent and reaction constants; the Taft treatment of polar and steric effects in aliphatic compounds*

3. ***Nucleophilic Substitution at Saturated Carbon****: Mechanism and Stereochemistry of SN1, SN2, SNi and SN2' reactions. The reactivity effects of substrate structure, solvent effects, competition between SN1 and SN2 mechanisms*

4. ***Electrophilic Aromatic Substitution****: The Arenium ion mechanism, orientation and reactivity in monosubstituted benzene rings, ortho/ para ratio. Ipso substitution*

5. ***Nucleophilic Aromatic substitution****: The Aromatic SN1, SN2 and benzyne mechanisms. Reactivtiy – effect of substrate structure, leaving group, and attacking nucleophile.*

6. ***Neighbouring Group Participation****: Evidences of N.G.P.; the phenonium ion, participation by π and σ bonds, Anchimeric assistance. Classical versus non-classical carbonium ions–the present status.*

Books recommended

1. M.B. Smith & Jerry March, *March's Advanced Organic Chemistry*, 5th Edition (2001), John Wiley & Sons, New York.
2. Peter Sykes, *A Guide book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman Ltd., New Delhi.
3. S. M. Mukherjee and S.P. Singh, *Reaction Mechanism in Organic Chemistry*, Ist Edition (1990), Macmillan India Ltd., New Delhi.
4. T.H. Lowry and K.S. Richardson, *Mechanism and Theory in Organic Chemistry*, 3rd Edition (1998), Addison – Wesley Longman Inc. (IS Edition)
5. P.S. Kalsi, *Organic Reactions and their Mechanisms*, 1st Edition (1996), New Age International Publication, New Delhi.

CHM104: Physical Chemistry-I

Credits:3

1. **Electrochemistry:** *Metal/Electrolyte interface***:** OHP and IHP, potential profile across double layer region, potential difference across electrified interface; Structure of the double layer: Helmholtz-Perrin, Gouy-Chapman, and Stern models. Butler-Volmer equation under near equilibrium and non-equilibrium

conditions, exchange current density, Tafel plot. Polarizable and non-polarizable interfaces.

*Semiconductor (SC)/electrolyte interface***:** Creation of space charge region**,** Capacity of space-charge, Mott-Schottky plots for n-type and p-type semiconductors, determination of flat-band potential and donor/acceptor densities. Application of SC/electrolyte interface in solar cells.

2. **Chemical Kinetics**: Mechanism of Composite Reactions - types of composite mechanisms, rate equations for composite mechanisms, simultaneous and consecutive reactions, steady state treatment, rate-determining steps, microscopic reversibility, dynamic chain (H_2-Br_2 reaction, decomposition of ethane and acetaldehyde) and oscillatory reactions (Belousov-Zhabotinskii reaction), branching chain: $H_2{}^+O_2$ reaction.
3. **Surface Chemistry and Catalysis**: Bimolecular surface reactions - reaction between a gas molecule and an adsorbed molecule, reaction between two adsorbed molecules, inhibition and activation energy of such reactions. Catalytic activity at surfaces (volcano curve), transition state theory of surface reactions: rates of chemisorption and desorption, unimolecular and bimolecular surface reaction, comparison of homogeneous and heterogeneous reaction rates, surface heterogeneity, lateral interaction
4. **Radiation Chemistry and measurement of radiations**: Interaction of nuclear radiation with matter, charged particles, neutrons and gamma-rays. Unit of radiation absorption, radiation dosimetry, radiolysis of water and some aqueous solutions, Ionization chamber, electron-pulse counters, electron multiplication in a gas, secondary processes, variation of pulse size with voltage, Types of G-M counters, absolute disintegration rate, Scintillation detector, semiconductor detectors, Neutron detectors.

Books Recommended:

1. *Modern Electrochemistry*, Vol. 2 A & B, J.O'M. Bockris and A. K. N. Reddy, 2nd Ed. Plenum Press, New York (1998).
2. *Chemical Kinetics*, K. J. Laidler, 3rd Ed. (1987), Harper & Row, New York.
3. *Physical Chemistry*, P. W. Atkins, 7th & 8th Eds., Oxford University Press, New York.
4. *Physical Chemistry*, I.N. Levine, 5th Ed., Tata McGraw Hill Pub. Co. Ltd., New Delhi.
5. *Essentials of Nuclear Chemistry*, H.J. Arnikar, 4th Ed. Wiley-Eastern Ltd., New Delhi.

Practical

CHM105: Inorganic Chemistry Practical

Credits: 2

1. Quantitative separation and determination of the following pairs of metal ions using gravimetric and volumetric methods:

   (i) Ag^+ (gravimetrically) and Cu^{2+}(Volumetrically)
   (ii) Cu^{2+} (gravimetrically) and Zn^{2+}(Volumetrically)
   (iii) Fe^{3+} (gravimetrically) and Ca^{2+}(Volumetrically)
   (iv) Mg^{2+} (gravimetrically) and Ca^{2+}(Volumetrically)

2. Separation of a mixture of cations/anions by paper chromatographic technique using aqueous/non-aqueous media.

   (i) Pb^{2+} and Ag^+ (aqueous and non-aqueous media)
   (ii) Co^{2+} and Cu^{2+} (non-aqueous medium)
   (iii) Cl^- and I^- (aqueous-acetone medium)
   (iv) Br^- and I^- (aqueous-acetone medium)

CHM106: Organic Chemistry Practical

Credits: 2

1. Determination of neutralization equivalent of organic acids.
2. Separation and Identification of compounds having one or more functional groups

CHM107: Physical Chemistry Practical

Credits: 2

1. Saponification of ethyl acetate with sodium hydroxide by chemical method.
2. Comparison of acid strengths through acid catalyzed methyl acetate hydrolysis.
3. Energy of activation of acid catalyzed hydrolysis of methyl acetate.
4. Distribution coefficient of I_2 between two immiscible solvents.
5. Conductometric titration of a weak acid with strong base.
6. Conductometric titration of a mixture of weak and strong acids.
7. Potentiometric titration of a strong acid with strong base using quinhydrone electrode.
8. Conductometric titration of KCl with $AgNO_3$.
9. Molecular weight of a non-electrolyte by cryoscopy method.
10. Plateau of GM tube and study of counting statistics.

CHM108M : Polymer Chemistry

Credits:3

1. Introduction, Classification of Polymers, Intermolecular forces in Polymers.

2. **Mechanism and kinetics of step-growth and chain growth polymerization:** radical, cationic, anionic and condensation polymerization. Copolymerization, Reactivity Ratios, Thermodynamic Aspects of Polymerization. Mechanism of Living Radical Polymerizations: Nitroxide mediated polymerization (NMP), Metal-catalyzed Living Radical Polymerization, Reversible Addition-Fragmentation Chain Transfer (RAFT) Radical Polymerization. Coordination polymerization, Ring opening polymerization, Types of polymerization process.

3. **Polymer solutions:** Thermodynamics of polymer dissolution, The Flory-Huggins Theory of Polymer solutions, Nature of polymer macromolecules in solution, Size and shape of macromolecules in solution.

4. **Polymer structure and Physical properties:** Microstructure of polymer chains, crystallinity in polymers, Glass transition temperature, rheological properties. Degradation of polymers. Polymer reactions. Polymer additives. Polymer Processing

5. **Experimental methods:** polymer synthesis, isolation and purification of polymers, polymer fractionation, molecular weight determination, molecular weight distribution curve, determination glass transition temperature..

6. **Specialty polymers:** Liquid crystalline polymer, Conducting polymers, Electroluminescent polymers, Inorganic Polymer. Nanocomposites of polymer.

Books Recommended

1. F. W. Billmayer, Jr., *Text Book of Polymer Science*, 3rd Edition (1984), Willey-Interscience, New York.
2. G. Odian, P. W. Atkins, *Physical Chemistry*, 6th Edition, Oxford University Press, New York.
3. G. Odian, *Principles of Polymerization*, 3rd edition (1991) John Wiley, Singapore
4. P.Bahadur and N.V. Sastry, Principle of Polymer Sciences , Narosa Publishing House, New Delhi (2002)
5. V.R. Gowarikar, N.V. Vishwanathan, J. Shreedhar , *Polymer Sciences*, Wiley Eastern, New Delhi (1986)

Semester-II

CHM201: Analytical Chemistry-II

(Techniques in Analytical Chemistry)

Credits:3

1. ***Polarography:*** Origin of polargraphy, Current-voltage relationship, Theory of polarographic waves (DC and sampled DC (tast) polarograms), Instrumentation, Ilkovic equation, Qualitative and quantitative applications.

2. ***Spectroscopic Techniques:*** Theory, Instrumentation and applications of X-rays (emission, absorption, diffraction and fluorescence methods), Atomic absorption Spectroscopy, Atomic fluorescence spectrometry, Atomic emission spectrometry

3. ***Spectroscopy***: UV-visible molecular absorption spectrometry (instrumentation and application), Molecular luminescence spectroscopy (fluorescence, phosphorescence, chemiluminescence).

4. ***Separation Methods:*** Principle of chromatography, Classifications of chromatography, Techniques of planar and column chromatography, Gas chromatography, High-performance liquid chromatography

5. ***Thermal Analysis:*** Theory, methodology and applications of thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), and Differential scanning calorimetry (DSC). Principles, techniques and applications of thermometric titration methods

Books Recommended

1. D.A. Skoog, *Principles of Instrumental Analysis*, 5th Edition (1998), Saunders College Publishing, Philadelphia, London.
2. G.W. Ewing, *Instrumental Methods of Chemical Analysis*, 5th Edition (1978), McGraw Hill Books Co., New York.
3. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, *Modern Methods of Chemical Analysis*, 2nd Edition (1976), John Wiley, New York.
4. J.H. Kennedy, *Analytical Chemistry: Principles*, 2nd Edition (1990), Saunders Holt, London.

CHM202: Inorganic Chemistry-II

Credits:3

1. **Kinetics and Mechanism of Substitution Reactions:** Nature of substitution reactions; prediction of reactivity of octahedral, tetrahedral and square-planar complexes in terms of crystal field activation energy and structure preference energy; rates of reactions; acid hydrolysis, base hydrolysis and anation reactions.

2. **Electron Transfer Reactions:** Mechanism and rate laws; various types of electron transfer reactions, Marcus-Husch theory, correlation between thermal and optical electron transfer reactions; identification of intervalence transfer bands in solution.

3. **Metal Carbonyls:** Preparation, structure, and properties: bonding in metal carbonyls, variants of CO bridging, vibrational spectra of metal carbonyls, principal reaction types of metal carbonyls. Carbonyl metal halides

4. **Optical Rotatory Dispersion and Circular Dichroism :** Basic Principles of ORD and CD techniques. ORD and Cotton effect, Faraday and Kerr effects; Applications in determining absolute configuration of metal complexes.

Books Recommended

1. F. Basalo and R. G. Pearson, *Mechanism of Inorganic Reactions*, 2nd Edn (1967), Wiley Eastern Ltd., New Delhi.
2. D. F. Shriver and P. W. Atkins, *Inorganic Chemistry*, 3rd Edn. (1999), ELBS, London.
3. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn. (1999), John Wiley & Sons, New York.
4. D.N. Sathyanarayana, *Electronic Absorption Spectroscopy and Related Techniques*, UniversitiesPress (India) Ltd., Hyderabad (2001).
5. Keith F. Purcell and John C. Kotz, *Inorganic Chemistry,* W. B. Sauders Com. (1987), Hong Kong.
6. Martin L. Tobe and John Burgess, *Inorganic Reaction Mechanisms,* Longmans Ist Edn. (1999).

CHM203 Organic Chemistry-II

Credits:3

1. **Addition to Carbon–Carbon Multiple Bonds:** Electrophilic, free-radical and nucleophilic addition: Mechanistic and Stereochemical aspects. Orientation and reactivity. Hydroboration and Michael reaction

2. **Esterification and Hydrolysis of Esters:** Evidence for tetrahedral intermediate in BAc2 and AAc2 mechanisms, steric and electronic effects. The AAc1 and other pathways involving alkyl to oxygen bond cleavage

3. **Elimination reactions:** The E1, E2 and E1cB mechanisms, Orientation of the double bond. Hofmann versus Saytzeff elimination, Pyrolytic *syn*-elimination, Competition between substitution and elimination reactions

4. **Kinetic Isotope Effects:** Its origin and importance in determining reaction mechanism. Solvent isotope effects.

5. **Conservation of Orbital Symmetry in Pericyclic Reactions:** Woodward-Hoffmann rules; cycloaddition [2+2] and [4+2], and electrocylic reactions. Prototropic and Sigmatropic rearrangements, Ene reactions and Cheletropic reactions; 1,3-Dipolar cycloaddition

Books recommended

1. M.B. Smith & Jerry March, *March's Advanced Organic Chemistry*, 5th Edition (2001), John Wiley & Sons, New York.
2. Peter Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman Ltd., New Delhi.
3. S. M. Mukherjee and S.P. Singh, *Reaction Mechanism in Organic Chemistry*, 1st Edition 1990), Macmillan India Ltd., New Delhi.
4. T.H. Lowry and K.S. Richardson, *Mechanism and Theory in Organic Chemistry*, 3rd Edition (1998), Addison – Wesley Longman Inc. (IS Edition).
5. P. S. Kalsi, *Organic Reactions and Their Mechanisms*, 1st Edition (1996), New Age International Pub., New Delhi.
6. S.M. Mukherjee and S.P. Singh, *Pericyclic Reactions*, MacMillan India, New Delhi.
7. I. Fleming, *Pericyclic Reactions*, Oxford University Press, Oxford (1999).

CHM204: Physical Chemistry-II

Credits:3

1 **Corrosion:** Scope and economics of corrosion, causes and types of corrosion, electrochemical theories of corrosion, kinetics of corrosion (corrosion current and corrosion potential). Corrosion measurements (weight loss, OCP measurement, and polarization methods), passivity and its breakdown. Corrosion prevention (electrochemical, inhibitor, and coating methods).
Cyclic Voltammetry: Instrumentation, current-potential relation applicable for Linear Sweep Voltammetry (LSV) and Cyclic Voltammetry (CV), interpretation of cyclic voltammograms and parameters obtainable from voltammograms

2 **Micelles:** Surface active agents and their classification, micellization, hydrophobic interaction, critical miceller concentration (cmc), factors affecting cmc of surfactants, thermodynamics of micellization: phase separation and mass action models, micro-emulsions, reverse micelles.
Polymer: definition, types of polymers, Molecular mass – number and mass average molecular mass, determination of molecular mass by Osmometry, viscosity, light scattering and size exclusion chromatography.

3 **Nuclear Chemistry**: Classification of nuclides, Nuclear stability, Atomic energy, Types of nuclear reactions-fission and fusion, Conservation in nuclear reactions-linear momentum and mass-energy, Reaction cross-section, Bohr's compound nucleus theory of nuclear reaction. Szilard-Chalmers reactions.
General characteristics of radioactive decay, decay kinetics, parent-daughter decay growth relationships, artificial radioactivity. Application of radioactivity- radiochemical principles, Isotope dilution and neutron activation analysis.

4 **Equilibrium and Non- equilibrium Thermodynamics**:

Properties of non-ideal solutions - deviations (negative and positive) from ideal behaviour, excess functions for non-ideal solutions, Third Law of thermodynamics: Nernst heat theorem, variation of entropy with temperature, determination of absolute entropy of liquids and gases, residual entropy.

Entropy production in irreversible processes, fluxes and forces, linear phenomenological relations, Onsager's reciprocity relations, thermodynamic theory of membrane permeability, reverse osmosis and electrokinetic phenomena.

Books Recommended

1. *Modern Electrochemistry*, J.O'M. Bockris and A. K. N. Reddy, Vol. 2 A & B, 2nd Edition, Plenum Press, New York (1998).
2. *Electrochemical Methods: Fundamentals and Applications*; A.J. Bard and L.R. Faulkner, 2nd edition (2001), John Wiley & Sons, New York.
3. *Micelles: Theoretical and Applied Aspects,* Y. Moroi, , Plenum Press, New York (1992).
4. *Text Book of Polymer Science,* F.W. Billmayer, Jr., 3rd Edition (1984), Wiley-Interscience, New York.
5. *Essentials of Nuclear Chemistry*, H.J. Arnikar, 4th Edition (1995), Wiley-Eastern Ltd., New Delhi.
6. *Physical Chemistry,* P. W. Atkins, 7th & 8th Editions, Oxford University Press, New York.
7. *Introduction of Thermodynamics of irreversible Processes*, I. Prigogine.

CHM205: Chemical Binding

Credits:3

1. Fundamental background: postulates and theorems of quantum mechanics. Angular momentum. Rigid rotor.

2. The Schrödinger equation and its exact solutions: the particle-in-a-box. Hydrogen atom. The variation theorem – ritz variation principle.

3. Atomic structure: many electron wave functions. Pauli exclusion principle. Helium atom. Atomic term symbols. The self-consistent field method. Slater-type orbitals.

4. Symmetry point groups: determination of point group of a molecule. Representations. The great orthogonality theorem. Character table. Construction of character tables for c_{2v} and c_{3v} groups. Symmetry adapted atomic basis sets. Construction of molecular orbitals. The direct product representation.

5. Molecular structure: Born-Oppenheimer approximation. Molecular orbital treatment for H_2^+. MO treatment of homo- and hetero nuclear diatomic molecules. Hückel mo treatment of simple and conjugated polyenes. Alternant hydrocarbons.

Books Recommended

1. *Quantum Chemistry*, I.N. Levine, 5th Edition (2000), Pearson Educ., Inc. New Delhi.
2. *Physical Chemistry: A Molecular Approach*, D.A. Mc Quarrie And J.D. Simon, (1998) Viva Books, New Delhi.
3. *Valence Theory*, J.N. Murrell, S.F.A. Kettle And J. M. Tedder, 2nd Edition (1965), John Viley, New York.
4. *Introductory Quantum Chemistry*, A.K. Chandra, 4th Edition (1994), Tata Mcgraw Hill, New Delhi.

Practical

CHM206 : Inorganic Chemistry Practical *Credits: 2*

1 Preparation of coordination complexes and their characterization by magnetic susceptibility measurements and IR, UV / Vis, ^{1}H NMR spectroscopic techniques.

CHM207 Organic Chemistry Practical

Credits: 2

1. Preparation and characterization of two and three steps organic compounds.
2. Isolation of caffeine from tea leaves.

CHM208 Physical Chemistry Practical *Credits: 2*

1. Rate constant of acid catalyzed hydrolysis of sucrose by polarimetric method.
2. Rate constant of acid catalyzed hydrolysis of sucrose by chemical method.
3. Rate constant of $FeCl_3$-catalyzed H_2O_2 decomposition by gasometric method.
4. Degree of hydrolysis of urea hydrochloride by kinetics method.
5. Equilibrium constant of $KI + I_2 \rightleftharpoons KI_3$ by distribution method.
6. Phase diagram of a binary organic system (Naphthalene and Diphenyl).
7. Determination of solubility and solubility product of sparingly soluble salt conductometrically.
8. Potentiometric titration of a redox system (ferrous ammonium sulfate with $K_2Cr_2O_7$).
9. Adsorption of acetic acid on charcoal to verify Freundlich adsorption isotherm.
10. Determination of half-life of a radionuclide.

CHM209M : Organic Chemistry-Applied Aspects

Credits:3

1. **Organic chemistry and industry**

2. **Life begins with nucleic acids**. Sugar alcohols, S-glycosides. vitamin-c and inositols

3. **Brief introduction of the following with context to life**: Aspirin, adrenaline, coniine, thujone, cholesterol, prostaglandins, penicillines.

4. **Crixivan**-organic Chemists' answer to HIV.

5. **Bio-polymers**: polysaccharides-starch, cellulose, sucrose, amino acids and polypeptides, proteins.

6. **Synthetic polymers**: properties and uses. Polyester, polytetrafluoroethelene, polyamino acids, polycyanoacrylates, polyurethanes, silicone rubbers, polymeric antioxidants, polyphosphazenes, divinylether-maleic anhydride cyclopolymer(DIVEMA)

Books Recommended

1. Yescombe, Sources of information on rubber, plastic and allied industries, Pergamon Press, 1968.
2. Peter Bernfeld,Biogenesis of Natural compounds,2nd edition, Pergamon press,1967.
3. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic chemistry, Oxford University press INC, New York, 2001
4. Harry R. Allcock, Frederick W. Lampe and James E. Mark, Contemporary Polymer Chemistry,3rd edition, Pearson Prentice Hall,2005

Semester-III

CHM301: Molecular Spectroscopy

(Core Paper)

Credits:3

1. **Time-dependent states and spectroscopy**: absorption and emission of radiation. Selection rules. Line shapes and widths. Fourier transform spectroscopy

2. **Rotation and Vibration of Diatomic Molecules**: Rigid Rotor and harmonic oscillator wave functions and energies. Selection rules. A review of MW and IR spectroscopy. Diatomic molecule wave functions-symmetry properties and nuclear spin effects. Raman effect: Rotational and vibration-rotational transitions. Vibration of polyatomic molecules–normal coordinates. Polarization of Raman lines. Resonance Raman and CARS spectroscopy.

3. **Electronic spectroscopy**: electronic spectroscopy of diatomic molecules. Franck-Condon factor. Dissociation and pre-dissociation. Rotational fine structure. Lasers and laser spectroscopy.

4. **Magnetic Resonance**: Review of angular momentum. Commutation relations. Basic principles and relaxation times. Magnetic resonance spectrum of hydrogen. First-order hyperfine energies. NMR in liquids: Chemical shifts and spin-spin couplings First order Spectra: A_3X, AX and AMX systems. Second order spectra: AB system. Equivalent nuclei. A_2B_2 system

5. **CW NMR**: The Spectrometer. Multiscan Principle (Cat)

6. **FT NNR**: Rotating frame of reference. Effect of rf pulse. FID. Multipulse operation. Measurement of T_1 by inversion recovery method. Spin echo and measurement of t_2

Book Recommended

1. J. M. Hollas, *Modern Spectroscopy*, 4th edition (2004) John Wiley & Sons, Ltd., Chichester.
2. C. N. Banwell and E.M. Mc Cash, *Fundamentals of Molecular Spectroscopy*, 4th edition (1994), Tata McGraw Hill, New Delhi.
3. A Carrington and A. D. Mc Lachlan, *Introduction to Magnetic Resonance*, Chapman and Hall, London (1979).
4. R. K. Harris, *Nuclear Magnetic Resonance Spectroscopy*, Addison Wesley, Longman Ltd, London (1986).

CHM302: Biological Chemistry

(Core Paper)

Credits:3

1. **Molecules of life**: Amino acids and proteins, Carbohydrates-polysaccharides, lipids, cell-membranes and nucleic acids

2. **Structure and function**: Protein structure, Ramachandran - plot, protein folding: DNA/RNA structures, various forms (a, b, c, z) of DNA, t-RNA structure, transcription and translation, gene expression and DNA binding protein-zinc-finger protein.

3. **Metabolism and Energetics**: Glycolysis , citric acid cycle , oxidative phosphorylation and transport through membranes

4. Enzyme kinetics, inhibition, drug action (selected examples)

5. **Metalloenzymes**: Hydrolytic and redox enzymes: Carbonic anhydrase and superoxide dismutase

6. **Oxygen uptake proteins**: Hemerythrin and hemocyanin

7. **Molecular recognition**: Molecular organization, Chiral recognition and role of sugar in biological recognition

Books Recommended

1. L. Stryer, Biochemistry, 5th Edition, (2002) Freeman &Co. New York
2. D.L. Nelson and M.M. Cox, Lehninger Principles of Biochemistry 3rd Edition ((2002) McMillan North Publication
3. D. Voet, J. G. Voet, Biochemistry 3rd Edition (2004), Wiley International Publication.
4. I. Bertini, H. B. Gray, S. J. Lippard, J.S. Valentine, 1st South Asian Edn., (1998) Viva Books Pvt. Limited, New Delhi
5. M. B. Smith, Organic Synthesis, (1998) Mc Graw Hill Inc, New York

Specialization Papers I & II

Analytical Chemistry Specialization

CHM303 (A): Principles of Analytical Chemistry

Credits:3

1. **Acid-Base Equilibria:** General concept of acid-base equilibria in water and in non-aqueous solvent, Definition of pH and pH scale (Sorenson and operational definitions), and its significance, Hammett acidity function, pH calculation for aqueous solutions of very weak acid and very weak base, salts of weak acid and weak bases, mixture of weak acid and its salts, mixture of weak base and its salts, polybasic acids and their salts, polyamines and amino acid, composition of solution of polybasic acid as a function of pH, protolysis curves

2. **Buffer Solutions:** Theory of buffer solution, dilution and salts effects on the pH of a buffer, Buffer index, Criteria and expression of maximum buffer capacity, Application of pH buffers, Preparation of buffer solutions of known ionic strength (Typical examples). Practical limitations in use of buffers, Metal ion buffers and their applications, Biological buffers and their applications.

3. **Photometric Titrations:** Basic principles, comparison with other titrimetric procedures, types of

photometric titration curves, Instrumentation (Titration cell, Detectors, choice of analytical wavelength). Quantitative applications, Typical examples of one component and multicomponent analyses.

4. **Chemical Sensors:** Principles, types of chemical sensors based on the modes of transductions, Types of chemical sensor based on the chemically sensitive materials (solid electrolyte, gas, semiconductor), Humidity sensors, Biosensors, Electrochemical sensors (Potentiometric sensors, Ion-selective electrodes, Membrane electrodes, Amperometric sensors, Clark and Enzyme electrodes).

Books Recommended

1. D.A. Skoog and D.M. West, *Fundamental of Analytical Chemistry*, International Edition, 7thEdition (1996), Saunders College Publishing, Philadelphia, Holt, London.
2. R.L. Pecsok, L.D. Shields, T. Cairns and L.C. McWilliam, *Modern Methods of Chemical Analysis*, 2nd (1976), John Wiley & Sons, New York.
3. D.A. Skoog, *Principles of Instrumental Analysis*, 5th Edition (1998), Saunders College of Publishing, Philadelphia, London.
4. H.A. Strobel, *Chemical Instrumentation: A Schematic Approach*, 2nd Edition (1973), Addison Wesley, Reading, Mass.

References

1. H.A. Laittnen and W.E. Harris, *Chemical Analysis*, 2nd International Student Edition (1960), McGraw Hill, New York.
2. R.G. Bates, *Electrometric pH Determinations: Theory and Practice*, 3rd Edition (1973), John Wiley & Sons, New York.
3. G.D. Moody and J.D.R. Thomas, *Ion-selective Electrodes*, London.
4. G.W. Ewing, *Instrumental Methods of Chemical Analysis*, 5th Edition (1978), McGraw Hill Book Co., New York.

CHM 304(A): Microanalytical Techniques

Credits:3

1. General Introduction: Scope and objectives of microanalytical technique, Difference between micro and trace analysis, Microanalytical technique based on size and amount of the sample

2. Microanalysis of real-world Samples: Molecular recognition and targeted analysis using macrocyclic (crown ethers), macrobicyclic (cryptands), Supramolecular compounds (calixarenes) and polymeric materials

3. Biochemical Microanalysis: Estimation of carbohydrates, amino acids and ascorbic acid in biological systems, Estimation of protein in egg albumin, Estimation of free fatty acid, Iodine value and saponification value of fats/oils, Estimation of blood cholesterol, DNA and RNA

4. Inorganic microanalysis: Principle, Technique, qualitative and quantitative applications with special reference to Ring-oven technique and Ring colorimetric technique, Chemical microscopy

5. Organic Microanalysis: Determination of alkoxy, acetyl, acyl, hydroxyl, carbonyl, active hydrogen, nitroso, sulfonyl, amides and ester groups, Determination of molecular weight and percentage purity of carboxylic acid, Estimation of sugars, Estimation of unsaturation

6. Microanalysis by Kinetic Methods: Theoretical basis, Kinetic parameters, Kinetic methods of microanalysis: Tangent, fixed time and addition method

Books Recommended

1. P.L. Kirk, *Quantitative Ultramicroanalysis*, John Wiley.
2. C.L. Wilson and D.L. Wilson, *Comprehensive Analytical Chemistry"*, Vol. I (A) and I(B), Elsevier.
3. G.D. Christian, *Analytical Chemistry*, John Wiley & Sons, New York (2001).
4. S.M. Khopkar, *Analytical Chemistry of Macrocyclic and Supramolecular Compounds*, Narosa Publishing House, New Delhi (2002).
5. Jag Mohan, *Organic Analytical Chemistry - Theory and Practice*, Narosa Publishing House, New Delhi (2003).

Inorganic Chemistry Specialization

CHM303 (I): Organometallic Chemistry of Transition Metals

Credits:3

1. **Inorganic π-Acid Ligands**: Dioxygen and dinitrogen, nitrosyl, tertiary phosphines and arsines as ligands.

2. **Complexes of σ-donor ligands**: Transition metal alkenyls, alkynyls, carbenes and carbynes

3. **π-complexes of unsaturated molecules**: Preparation, bonding and structure of alkene, alkyne, allyl, dienyl and trienyl complexes; reactions with special reference to organic synthesis

4. **Transition metal compounds in catalysis**: Hydrogenation, hydroformylation and polymerization; Waker Process

5. **Transition metal Compounds with M-H bonds**: Metal hydrides (classical and non-classical). Agostic interaction. Application of NMR in studying hydrido complexes

Books Recommended

1. F.A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6^{th} Ed. (1999) John Wiley & Sons, NY.
2. J.E. Huheey, Keiter and Keiter, Inorganic Chemistry,
3. R. H. Crabtree, The Organometallic Chemistry of Transition Metals, John Wiley.
4. Ch. Elschenbroich and A. Salzer, Organometallics, VCH.
5. J.P. Collman, L.S. Hegedus, J.R. Norton and R.G. Finke, Principles and Applications of Organotransition metal Chemistry, Univ. Sci. Books, Mill Valley. California.

CHM304 (I): Bio-inorganic Chemistry

Credits:3

1. **Role of alkaline earth metal ions in biological systems :** (i) Catalysis of phosphate transfer by Mg^{2+} ion, (ii) Ubiquitous regulatory role of Ca^{2+} - muscle contraction

2. **Iron, copper and molybdenum proteins with reference to their oxygenation and oxidase activity:** (i) Anti-oxidative functions: cytochrome P-450, catalases and peroxidases, (ii) Nitrate and nitrite reduction: NO_3 and NO_2 reductase, (iii) Electron transfer: cytochromes; blue copper proteins and iron-sulfur proteins and their Synthetic models, (iv) molybdo-enzymes – molybdenum cofactors : molybdenum-pterin complexes, (v) Nitrogen fixation through metal complexation, nitrogenase, (vi) Photosynthesis (PS-I and PS-II).

3. **Metalloenzymes:** Urease, Hydrogenase, and Cyanocobalamine

4. **Interaction of metal complexes with DNA:** DNA probe and chemotherapeutic agents

5. **Iron storage and transport proteins:** Ferritin, Transferritin and Hemosiderin

Books recommended

1. M. N. Hughes, *Inorganic Chemistry of Biological Processes*, 2nd Ed.(1981), John-Wiley & Sons, New York.
2. W. Kaim and B. Schwederski, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide*, Wiley, New York (1995).
3. S. J. Lippard and J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books, (1994).
4. I. Bertini, H. B. Grey, S. J. Lippard and J. S. Valentine, *Bioinorganic Chemistry*, Viva Books Pvt. Ltd., New Delhi (1998)

Organic Chemistry Specialization

CHM303 (O): Stereochemistry and Photochemistry

Credits:3

1. **Stereochemistry:** Enantioselcetive synthesis with chiral non racemic reagents and catalysts: Hydroboration with chiral boranes ($I_{PC}BH_2$), $(I_{PC})_2BH$, Carbonyl group reduction with chiral complex hydride (BINAL-H, Chiral oxazaborolidines), Chiral organometal complex –(-)DAIB; 3-exo-dimethylamino isoborneol. Enantioselective epoxidation of alkene: Sharpless epoxidation, enantioselective hydrogenation with$[Rh(DIPAMP)]^+$. Diastereoselective synthesis:Aldol reactions (Chiral enolate & Achiral Aldehyde and Achiral enolate and chiral aldehyde). **Optical** Activity in absence of chiral carbon: biphenyls and Allenes and Atropisomerism.

2. **Conformation:** Shape of six membered rings and decalines; conformational analysis based on physical properties and chemical reactivity in substituted cyclohexane/ cyclohexene.

3. **Photochemistry:**

   (a) Introduction and Basic Principles of Photochemistry: Absorption of light by organic molecules, properties of excited states, mechanism of excited state processes and methods of preparative photochemistry.

   (b) Photochemistry of alkenes and related compounds: Isomerization, Di-π-methane rearrangement and cycloadditions.

   (c) Photochemistry of aromatic compounds: Ring isomerization and cyclization reactions.

   (d) Photochemistry of carbonyl compounds: Norrish type-I cleavage of acyclic, cyclic and α, β and β, γ unsaturated carbonyl compounds, Norrish type-II cleavage. Hydrogen abstraction: Intramolecular and intermolecular hydrogen abstraction, photoenolization. Photocyclo-addition of ketones with unsaturated compounds: Paterno-Buchi reaction, photodimerisation of α, β- unsaturated ketones, rearrangement of enones and dienones, Photo-Fries rearrangement

4. **Rearrangements:** Sommelet-Hauser, Favorskii, rearrangements. Hofmann-Loffler-Freytag reaction, Barton reaction and Shapiro reaction.

Books Recommended

1. M.B. Smith and J. March, *March's Advanced Organic Chemistry-Reactions, Mechanisms and Structure*, 5th Edition (2001), John Wiley & Sons, New York.
2. D. Nasipuri, *Stereochemistry of Organic Compounds*, 2nd Edition (1994), Wiley Eastern Ltd., New Delhi.
3. J. Aube and R. E. Gawley, *Principles of Asymmetric Synthesis.*
4. E.L. Eliel, S.H. Wilen and L.N. Mander, *Stereochemistry of Organic Compounds*, Wiley Interscience, New York (2004).
5. Paul de Mayo, *Molecular Rearrangements*, Vol.I & II, Interscience Publishers, New York (1963).
6. John D. Coyle, *Introduction to Organic Photochemistry*, John Wiley and Sons, New York (1986).
7. C.H. Depuy and O.L. Chapman, *Molecular Reactions and Photochemistry*, 2nd Edition (1988), Prentice-Hall of India (P) Ltd., New Delhi.
8. F.A. Carey and R.J. Sundberg, *Photochemistry* in *Advanced Organic Chemistry*, Chapter 13, Part A, 3rd Edition (1990), Plenum Press, New York.
9. N. J. Turro, *Modern Molecular Photochemistry,* University Science Books, Sausalito (1991).

CHM304 (O): Natural Products

Credits:3

1. **Alkaloids:** Structure elucidation of alkaloids – a general account; Structure, synthesis, and stereochemistry of Narcotine and Quinine; synthesis and stereochemistry of Morphine, Lysergic acid and Reserpine.

2. **Terpenoids:** Camphor, Longifolene*, Abietic acid, and Taxol.

3. **Steroids:** Cholesterol, Cortisone*, and Aldosterone*.

4. **Prostaglandins and Thromboxanes :** Introduction, nomenclature of prostaglandins and thromboxanes; approaches to prostaglandin synthesis; cyclohexane precurors (Woodward synthesis of PGF2a), bicycloheptane precursors (Corey's synthesis of prostaglandins E and F)

5. Retrosynthetic Analysis of morphine and reserpine and Longifolene**.**

*** Synthesis only.**

Books Recommended

1. Nitya Anand, J.S. Bindra and S. Ranganathan, *Art in Organic Synthesis*, 2nd Edition (1970), Holden Day, San Francisco.
2. S.W. Pelletier, *Chemistry of the Alkaloids*, Van Nostrand Reinhold Co., New York (1970).
3. K.W. Bentley, *The Alkaloids*, Vol. I., Interscience Publishers, New York (1957).
4. I. L. Finar, *Organic Chemistry*, Vol. II, 5th Edition (1975) Reprinted in 1996, ELBS and Longman Ltd, New Delhi
5. J.W. Apsimon, *Total Synthesis of Natural Products*, Vol. 1-6, Wiley-Interscience Publications, New York.
6. J.S. Bindra and R. Bindra , *Creativity in Organic Synthesis*.
7. J.S. Bindra and R. Bindra, *Prostaglandins Synthesis*.
8. K. C. Nicolaou, *Classics in Total Synthesis of Natural Products,* Vol. I & II.
9. J. Clayden, N. Greeves, S. Warren, and P. Wothers, *Organic Chemistry, Chapter 30,* Oxford University Press, Oxford (2001).

Physical Chemistry Specialization

CHM303 (P): Electrochemistry

Credits:3

1. **Activity Coefficient and Ionic Migration in Electrolyte Solutions:** Quantitative treatment of Debye-Hückel theory of ion-ion interaction and activity coefficient, applicability and limitations of Debye-Hückel limiting law, its modification for finite-sized ions, effect of ion-solvent interaction on activity coefficient. Debye-Hückel-Onsagar (D-H-O) theory of conductance of electrolyte solution, its applicability and limitations, Pair-wise association of ions (Bjerrum and Fuoss treatment), Modification of D-H-O theory to account for ion-pair formation, Determination of association constant (K_A) from conductance data.

2. **Electrical Double Layer at Metal/Electrolyte Interface:** Thermodynamics of double layer, Electrocapillary equation, Determination of surface excess and other electrical parameters-electrocapillarity, excess charge capacitance, and relative surface excesses. Metal/ water interaction-Contact adsorption, its influence on capacity of interface, Complete capacity- potential curve, Constant capacity region hump. Specific adsorption-extent of specific adsorption

3. **Electrode Kinetics:** Review of Butler-Volmer treatment. Polarizable and non-polarizable interfaces. Multistep reactions- a near equilibrium relation between current density and over potential, Concept of rate determining step. Determination of reaction order. stochiometric number, and transfer coefficient. Electrocatalysis-comparison of electrocatalytic activity. Importance of oxygen reduction and hydrogen evolution reactions and their mechanisms.

4. **Electrochemical Techniques:** Impedance technique-its application for studying electrode kinetics and corrosion.

   Rotating Disc Electrode (RDE): Application of for measurement of electrochemical rate constant**.**

Books Recommended

1. *Modern Electrochemistry*, Vol. 1 & 2A and 2 B, J.O'M. Bockris and A.K.N. Reddy,Plenum Press, New York (1998).
2. *Electrochemical Methods: Fundamentals and Applications*; A.J. Bard and L.R. Faulkner, 2nd edition (2001), John Wiley & Sons, New York.

CHM304 (P): Quantum Chemistry

Credits:3

1. **Fundamentals:** Review of Classical Mechanics. General formulation of Qunatum Mechanics. Review of angular momentum, rigid rotor, harmonic oscillator and H- atom problems.

2. **Approximation Methods:** Stationary perturbation theory for non-degenerate and degenerate systems with examples. Variation method. Ground state of He atom. Time-dependent perturbation theory. Radiative transitions. Einstein coefficients.

3. **Many Electron atoms**: Hartree SCF method, Electron correlation, Addition of angular momenta– Clabsch-Gordan series, Term symbols for two equivalent electrons, Total angular momentum and spin-orbit interaction. Condon Slater Rules.

4. **Group Theory:** Review and Applications**.**

5. **Ab initio Methods for Closed Shell Systems:** Review of molecular structure calculations, dipole moments. Hartree-Fock method for molecules. Roothaan-Hartree-Fock method. Selection of basis sets. Density functional Method. Population analysis.

Books Recommended

1. P.W. Atkins and R.S. Friedman, *Molecular Quantum Mechanics,* 3rd edition (1997), Oxford University Press. Oxford.
2. H. Eyring, J. Walter and G.E. Kimball, *Quantum Chemistry,* John Wiley, New York (1944)
3. I.N. Levine, *Quantum Chemistry*, 5th edition (2000), Pearson Educ., Inc., New Delhi.

Practical

CHM305 (A): Analytical Chemistry Practical *Credits: 6*

1. Determination of ferrous ammonium sulfate potentiometrically with standard ceric sulfate solution (Direct and back titration).
2. Determination of concentration of halide ion(s) in the given solution potentiometrically.
3. Conductometric titration of (I) strong acid, monobasic weak acid or polybasic weak acid with strong base (ii) zinc with EDTA, and (iii) KCl vs $AgNO_3$
4. To obtain the protolysis curves involving cases of weak acid, mixture of acids and polybasic acid employing a pH meter and determine the amount of the respective acid (in ppm) in the given solution
5. Determination of Na_2CO_3 content (in %) of washing soda using a pH meter
6. Analysis of mixture of carbonate and bicarbonate (percent in ppm range) using a pH meter or suitable indicators
7. To study the current-potential characteristics of Cd^{2+} ions using DC polarography, sampled DC, cyclic voltammetry and pulse polarographic techniques
8. Determination of Cd^{2+} ions concentration in given solution polarographically following (I) calibration (ii) standard addition and (iii) the pilot-ion procedures
9. Determination of Zn^{2+} ions present at the ppm level in the solution employing conventional D.C.and pulse polarographic techniques
10. Determination of trace metal impurities present in a polluted water sample by anodic stripping voltammetric procedure
11. **Statistical Treatment of Results**
    1. Determination of accuracy, precision, mean deviation, standard deviation, coefficient of variation, normal error curve and least square fitting of certain set of experimental data in an analysis.
    2. Composition of two sets of results in terms of significance (Precision and accuracy) by (I) student's t-test, (ii) F-test
12. Solvent Extraction: Determination of Fe (III) by chloride extraction in ether
13. Complexometric and Redox Titrations
    1. Metal-EDTA titrations using Eriochrome Black T, Xylenol orange and PAN indicators (only back titration or substitution titration methods).
    2. Estimation of the purity of oxalic acid employing standard Ce (IV) solution.
14. Spectrophotometric Analysis
    1. Spectrophotometric determination (in ppm) of Fe (II) or Fe(III) using 1,10 Phenanthroline (or thiocyanate) as colorimetric reagent.
    2. Colorimetric determination of chromium (VI) (in ppm) using 1,5 diphenyl carbazide as a reagent for colour development
15. Quantitative analysis of APC tablet by NMR or IR spectroscopy
16. Water Analysis: Analysis of water samples for the following parameters
    (I) BOD, (ii) COD, (iii) Dissolved oxygen, (iv) total phosphorous, (v) sulfur as SO2, (vi) total hardness and chloride, (vii) total dissolved solids.
17. To prepare a buffer solution of known ionic strength and to find its maximum buffer capacity

CHM305(I):Inorganic Chemistry Practical *Credits: 6*

Section-A

1. (a) Synthesis and structural characterization (IR, electronic spectra and magnetic susceptibility) of $[Ni(py)_4(NCS)_2]$.
   (b) Synthesis of a series of Ni(II) complexes (with ligands of varying ligand field strength), electronic spectral interpretation and calculation of various ligand-field parameters.
2. Synthesis and structural characterization (IR, Electronic spectra) of the *cis*- and *trans*-isomers of $[Co(en)_2Cl_2]$
3. Synthesis and characterization (IR and PMR & CMR) of $[Al(acac)_3]$

Section-B

1. Synthesis, purification by sublimation and structural characterization (IR and electronic spectra) of ferrocene.
2. Acetylation of ferrocene and separation of the acetyl derivative by column chromatography.

CHM305(O): Organic Chemistry Practical *Credits: 6*

1. Separation and identification of organic mixtures containing up to three components.
2. Preparation of organic compounds involving several stages, characterization of intermediates and final products by IR and NMR spectroscopy.
3. Techniques of organic chemistry: Special practical's involving steam distillation, photoisomerisation and thin layer chromatography etc.
4. Quantitative analysis of (i) Sulphur and (ii) nitrogen.

CHM305 (P): Physical Chemistry Practical *Credits: 6*

1. Kinetics of decomposition of benzene diazonium chloride.
2. Conductometric study of the kinetics of saponification of ethyl acetate.
3. Determination of transport numbers of Cu^{2+} and SO_4^{2-} by Hittorf's method.
4. Conductometric titration of triple mixture ($HCl+NH_4Cl+KCl$) with (i) NaOH and (ii) $AgNO_3$.
5. Analysis of halide mixture by differential potentiometry.
6. Conductometric titration of a polybasic acid.
7. Verification of the Nernst law of electrode potential.

8. Determination of band-gap of a semiconductor.
9. Ternary phase diagram of water, benzene, and acetic acid.
10. Determination of molecular weight of a macromolecule by viscometry.
11. Half-life periods of a source containing two radionuclides.
12. Absorption coefficient of metal absorbers for ^{60}Co γ - rays.
13. Electrochemical Impedance study of metal/solution interface.
14. Cyclic Voltammetry of the $[Fe(CN)_6]^{3-}/[Fe(CN)_6]^{4-}$ system.
15. Corrosion study of steel in an acid solution.

Elective Papers

Elective-I (Group A)

CHM306: Forensic Analysis

Credits:3

1. **Introduction:** Profile of a forensic laboratory, Forensic Scientists role and quality control, Crime-scene investigation, Collection and preserving physical evidences and evidentiary documentation, Future prospects of forensic analysis

2. **Real Case Analysis:** Liquor analysis, Trap-case analysis, Petroleum product analysis, Fire and Debris analysis, Injuries, Firearm wounds, Asphyxia and stress analysis (only analytical identifications).

3. **Forensic Toxicology:** Analysis of various types of poisons (corrosive, irritant, analgesic, hypnotic, tranquillizer, narcotic, stimulants, paralytic, antihistamine, domestic and industrial (gaseous and volatile) poisoning and food poisonings), Explosive and explosion residue analysis, Lethal drug analysis (sampling, sealing, packing, laboratory methods of testing, reporting the analysis results, court evidence and medico-legal aspects for the consideration of chemical data as a proof for crime), Importance of physiological tests in forensic toxicology

4. **Instrumentation for Forensic Analysis**

5. **(a)** ***Physical, Biological and Chemical Methods:*** Non-destructive testing probes including radiography, Xera-radiography, Surface penetrations method (SEM and Laser Probes), Fluoroscopy, Clinical methods: ELISA, RIA and immunodiffusion , analysis of glucose, bilirubins, total cholesterol , creatinine, blood urea nitrogen and barbiturates in biological fluids, DNA-finger printing, Examination and grouping of blood strains and seminal strains, Data retrieval and automation techniques for forensic examination with reference to presence of drugs, glasses, paints, oils and adhesives at crime spot.

   (b) ***Instrumental Methods:*** Sample preparation, Calibration of the instruments for its accuracy and producibility of results in forensic analysis, Method validation technique and requirements, Procurement of standard samples, Forensic applications of TLC, HPTLC, HPLC, GC, FT-IR, AAS, GC-MS, UV-visible spectrophotometer with emphasis over standard operational procedures (SOPs) for test samples.

Books Recommended

1. W.J. Welcher (Ed.), *Scott's Standard Methods of Chemical Analysis*, Vol. III A, 6th Edition (1966), and vol. III B, 5th Edition (1975), Van Nostrand Reinhold Co. London.
2. Peter Fordham, *Non-destructive Testing Techniques,* 1st edition (1968), London Business Publications Ltd., London
3. W. Horwitz, *Official Methods of Analysis*, 11th Edition (1970), Association of Official Analytical Chemists, Washington DC.
4. K. Simpson and B. Knight, *Forensic Medicine*, 9th Edition (1985), Edward Arnold Publishers Ltd., London.

CHM307: Chemical Applications of Group Theory

Credits:3

1. **Group Theory in Chemistry:** Classification of Groups; Matrix representation of symmetry elements and point groups, matrices of C_{3v} and C_{4v} point groups, transformation matrices; Structure of character tables, determination of symmetry species for translations and rotations, Construction of Character tables (C_{2v}, $C_{3v,}$ C_{4v} groups)

2. **Chemical Applications of Group theory**

3. **IR and Raman Spectroscopy:** Brief introduction to molecular vibrations; selection rules for fundamental vibrational transitions, symmetry of normal modes of molecules, Infrared and Raman activity of some typical molecules (molecules of C_{2v}, $C_{3v,}$ C_{4v}, D_{2h}, D_{3h}, and D_{4h} point groups)

4. **Crystal Field Theory:** Splitting of levels and terms in chemical environment, construction of energy level diagrams, selection rules and polarizations.

5. **Molecular Orbital Theory:** Introduction, transformation properties of atomic orbitals; hybridization schemes for σ- and π-bonding, hybrid orbitals as LCAOs; Molecular Orbital Theory for some typical AB_n types (n = 2, 3, 4, 6) of molecules (H_2O, NH_3 and BH_3)

6. **Electronic Spectra:** General considerations, typical examples from tetrahedral and octahedral systems, Orgel energy level diagrams

Books Recommended

1. F. A. Cotton, *Chemical Applications of Group Theory*, 3rd Edn. (1999), John Wiley & Sons, New York.

2. G. L. Miessler and D. A. Tarr, *Inorganic Chemistry*, 2nd Edn. (1999), Prentice Hall International Inc., London.

3. K. Veera Reddy, *Symmetry and Spectroscopy of Molecules*, New Age International Pvt. Ltd., New Delhi (1999).

CHM308 : Medicinal Chemistry

Credits:3

1. **Structure and activity:** Relationship between chemical structure and biological activity (SAR). Receptor Site Theory. Approaches to drug design. Introduction to combinatorial synthesis in drug discovery

2. **Drugs based on a substituted benzene ring:** Chloramphenicol, salmeterol, tolazamide, diclophenac, tiapamil, intryptyline

3. **Drugs based on five membered heterocycles :** Tolmetin, spiralpril, oxaprozine, sulconazole, nizatidine, imolamine, isobuzole.

4. **Drugs based on six membered heterocycles :** Warfarin, quinine, norfloxacin and ciprofloxacin, methylclothiazide, citrine, terfenadine.

5. **Drugs based on seven membered heterocyclic rings fused to benzene:** Chlordiazepoxide, diazepam, diltiazem.

6. **Drugs based on heterocycles fused to two benzene rings:** Quinacrine, tacrine,

7. **β-Lactam antibiotics:** Penicillin, cephalosporin.

8. **Drugs besed on five membered heterocycles fused to six membered rings:** Acyclovir, methotrexate.

Books Recommended

1. A. Burger, *Medicinal Chemistry*, Vol. I-III, (1995) Wiley Interscience Publications, New York.
2. W. O. Foye, *Principles of Medicinal Chemistry*, 3rd Edition (1989), Lea & Febiger/ Varghese Publishing House, Bombay.
3. D. Lednicer and L. A. Mitscher, *The Organic Chemistry of Drug Synthesis*, Vol. I-III, Wiley Interscience.
4. A. Kar, *Medicinal Chemistry*, (1993) Wiley Eastern Ltd., New Delhi.
5. N. K. Terrett, *Combinatorial Chemistry,* (1998) Oxford Univ. Press, Oxford.
6. Daniel Lednicer *Stretegies for organic drug synthesis and design,* John Wiley & Sons, New York.

CHM309: Physical Methods in Chemistry

Credits:3

1. **Photoelectron Spectroscopy and Related Techniques:** Principle and applications to studies of molecules and surface. UPES and XPS. Auger electron and X-ray fluorescence spectroscopy (AES and XRF).

2. **Techniques for Studying Surface Structure:** Low energy electron diffraction (LEED). Scanning tunneling and atomic force microscopy (STM and AFM).

3. **Neutron Diffraction:** Principle and applications.

4. **Fluorescence techniques:** Steady state fluorescence spectroscopy. Time-resolved (Time correlated single photon counting-TCSPC) fluorescence spectroscopy. Introduction to Single molecule fluorescence and fluorescence imaging.

Books Recommended

1. J.M. Hollas, *Modern Spectroscopy,* 4th edition (2004), John Wiley and Sons, Chichester.
2. C.N. Banwell and E.M. Mc Cash, *Fundamentals of Molecular Spectroscopy*, 4th edition (1994), Tata McGraw Hill, New Delhi.
3. E.M. Mc Cash, *Surface Chemistry*, Oxford University Press, Oxford (2001).
4. A.K. Cheetham and P Day, *Solid State Chemistry Techniques*, Oxford Univ. Press, Oxford (1988).
5. Joseph R. Lakowicz, *Fluorescence Spectroscopy*, 2nd edition, Plenum Press, New York. (1999).

Semester-IV
CHM401: Computer Applications in Chemistry (Core Paper)

Credits:2

1 **FORTRAN 77:** Types of Constants and Variables in Fortran, Dimension, Data, Type, COMMON and EQUIVALENCE statements, Arithmetic and Logical IF, IF-THEN-ELSE Constructs, DO statement, Various types of I/O statements, Library functions, Statement functions, Function Subprograms and subroutine subprograms.

2 **Numerical Methods:** Roots of Polynomials, Solution of Linear simultaneous equations, matrix multiplication and inversion. Numerical integration. Statistical treatment of data, variance and correlations.

Books Recommended

1. V. Rajaraman, *Fortran 77*, Prentice Hall (India), New Delhi.
2. C. Xavier, Fortran 77 and Numerical Methods, New Age International Pvt. Ltd. Publishers, New Delhi
3. S. Lipschutz and A. Poe, Schaum's Outline Series – Theory and Problems of Programming with Fortran including structured Fortran, Mc Graw Hill Book Company, Singapore
4. K. V. Raman, *Computers in Chemistry,* Tata McGraw Hill (1993). [Reference book]

Specialization Papers III-V

Analytical Chemistry Specialization

CHM 402(A): Separation Techniques

Credits:3

1. **Separation Techniques Based on Phase Equilibria** : Principles of analytical separation: Plate theory, rate theory, Craig concept of counter current distribution, process optimization, Retention analysis; Resolution (Fundamental equation). Distillation: Fractional distillation, Molecular distillation. Chromatography: Gas chromatography, Liquid chromatography (including high performance chromatography), Ion-exchange chromatography, Ion chromatography, Size exclusion chromatography, Planar chromatography (PC, TLC, HPTLC), Reverse phase chromatography & Bonded phase chromatography (BPC), Super critical fluid chromatography (SFC). Solvent Extraction: Liquid-Liquid and super critical fluid extraction, Quantitative treatment of various Solvent, extraction equilibria. Sublimation: Normal and vacuum sublimation. Crystallisation: Zone refining and Fractional.

2. **Separation Techniques Based on Rate Processes**: (a) Barrier-separation methods: Membrane separation-Ultrafiltration, dialysis, electrodialysis, electro-osmosis, reverse osmosis(b) Field separation methods: Electrophoresis, Ultracentrifugation

Books Recommended

1. G.H. and H. Freiser, *Solvent Extraction in Analytical Chemistry*, 1st Edition (1958), John Wiley, New York.
2. B.L. Karger, L.R. Snyder and C. Howarth, *An Introduction to Separation Science*, 2nd Edition (1973), John Wiley, New York.
3. E.W. Berg, *Chemical Methods of Separation*, 1st Edition (1963), McGraw Hill, New York.
4. D.G. Peters, J.M. Hayes and C.M. Hieftj, Chemical *Separation and Measurements*, 2nd Edition (1974), Saunders Holt, London.
5. J.D. Seader and E.J. Henley, *Separation Process Principles*, 1st Edition (1998), John Wiley & Sons. Inc., New York.

CHM403 (A): Electroanalytical Methods

Credits:3

1. **General Introduction**: Overviews of Electrode Processes, Electrocapillary curve and electrocapillary maximum potential, Exchange current, Polarisation and overvoltage, Reference electrodes. Mercury electrodes (DME, SME, HMDE), Rotating platinum electrode. Three-electrode system.

2. **Polarography:** Origin of polarography, Interpretation of a polarographic curve. Instrumentation. Limiting current, residual and charging current, diffusion current, migration current. Supporting electrolytes. Effect of supporting electrolyte on the limiting current. Diffusion coefficient and its evaluation. Ilkovic equation, its derivation and applications. Estimation of n-value(s). Theory and equations of different current-potential curves. Criteria of polarographic reversibility. Quasi-reversible and irreversible processes. Half-wave potentials and their significance. Interpretation of catalytic, kinetic, adsorption and capacitive currents. Polarographic maxima and maximum suppresors. Methods of quantitative analysis: absolute, comparative, the PILOT ION and kinetic methods

3. **Modern Polarography:** Necessity and development of new voltammetric techniques and their comparison with classical polarography. Fundamentals of sampled DC polarography (Tast), oscilliography, differential and derivative voltammetry, cyclic, pulse, alternating current and square wave polarography

   Related Techniques: Amperometric titration, Chronoamperometry, Chronopotentiometry. Controlled-potential and constant current coulometry. Stripping analysis, Electrogravimetry, Electrography and Electro-spot testing

Books Recommended

1. L. Meites, *Polarographic Techniques*, 2nd Edition (1965), John Wiley, New York.
2. J. Heyrovsky and K. Kuta, *Principles of Polarography*, 1st Edition (1966), Academic Press, New York.
3. D.A. Skoog, F.J. Holler and T.A. Nieman, *Principles of Instrumental Analysis*, 5th Edition (1998), Saunders College Publishing, Harcourt Brace & Company, U.S.A.
4. A.J. Bard and L.R. Faulkner, *Electrochemical Methods: Fundamentals and Applications*, 2nd Edition (2000), Wiley, New York.

Additional References

1. I.M. Kolthoff and J.J. Lingane, *Polarography*, 2nd Edition (1952), Wiley Intersciences, New York.
2. C.W.C. Milner and G. Phillips, *Coulometry in Analytical Chemistry*, Pregamon Press, New York (1967).

CHM404 (A): Spectrochemical Analysis

Credits:3

1. **Infrared Spectroscopy:** Infrared instruments, typical applications of infrared spectroscopy (qualitative and quantitative).

2. **Raman Spectroscopy:** Raman spectroscopy, Instrumentation, Analytical applications of Raman spectroscopy

3. **Nuclear Magnetic Resonance Spectroscopy:** Theory of nuclear magnetic resonance, Environmental effects on NMR spectrometers, Applications of proton NMR, C13 NMR, Two dimensional Fourier-transform NMR, Magnetic resonance imaging (MRI), Quantitative applications of NMR: Drug Analysis, Molecular Weight determination.

4. **Electron Spin Resonance Spectroscopy:** Theory, Instrumentation and Important analytical applications

5. **Electron Spectroscopy:** Theory, Instrumentation and applications of Electron spectroscopy (ESCA and Auger), Scanning electron microscopy (SEM), Scanning tunnelling microscopy (STM) and Atomic force microscopy (AFM).

6. **Plasma Emission Spectroscopy:** Theory, Instrumentation and Analytical applications of inductively coupled plasma emission spectroscopy (ICPE).

7. **Applications in analysis of special materials:** Analysis of dairy products**,** food additives, petrochemicals (including liquid and gaseous fuels), drugs and pharmaceuticals and fertilizers

Books Recommended

1. D.A. Skoog, F.J. Holler and T.A. Nieman, *Principles of Instrumental Analysis*, 5th Edition (1998), Harcourt Brace & Company, Florida.
2. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern *Methods of Chemical Analysis*, 2nd Edition (1976), John Wiley, New York.
3. J.M. Hollas, *Modern Spectroscopy*, 3rd Edition (1996), John Wiley, New York.
4. H.A. Strobel, *Chemical Instrumentation – A Systematic Approach*, 2nd Edition (1973), Addison Wesley, Mass.
5. D.C. Garratt, *the Quantitative Analysis of Drugs*, 2nd Edition (1992), Chapman and Hall Ltd., London.
6. W. Horwitz (Editor), *Official Methods of Analysis*, 11th Edition (1970), Association of Official Analytical Chemists, Washington DC.

Inorganic Chemistry Specialization

CHM402 (I): Structural Methods in Inorganic Chemistry

Credits:3

1. **NMR Spectroscopy:** (i) Use of Chemical shifts and spin-spin couplings for structural determination, (ii) Double resonance, and Dynamic processes in NMR, (iii) Decoupling phenomenon, Nuclear Overhauser Effect, DEPT spectra and structural applications in ^{13}C NMR, (iv) Use of Chemicals as NMR auxillary reagents (shift reagents and relaxation reagents (v) ^{1}H NMR of paramagnetic substances. (VI) NMR of Metal nuclei

2. **Electron Spin Resonance Spectroscopy:** Basic principle, Hyperfine Splitting (isotropic systems); the *g*-value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy); Electron-electron interactions, Anisotropic effects (the *g*-value and the hyperfine couplings); Structural applications to transition metal complexes

3. **Mössbauer Spectroscopy:** Basic principle, conditions for Mossbauer spectroscopy, Spectral parameters (Isomer shift, electric quadrupole interactions, magnetic interactions), temperature dependent effects, structural deductions for iron and tin complexes, miscellaneous applications.

4. **Infrared and Raman Spectroscopy:** Applications of vibrational spectroscopy in investigating (i) symmetry and shapes of simple AB2, AB3 and AB4 molecules on the basis of spectral data, (ii) mode of bonding of ambidentate ligands (thiocyanate, nitrate, sulphate and urea).

5. **Mass Spectrometry:** Fragmentation pattern and Fingerprint applications in the interpretation of Mass spectra, effect of isotopes on the appearance of mass spectrum, recognition of the molecular ion peak; Ionization techniques (EI and FAB)

Books Recommended

1. E. A. V. Ebsworth, D. W. H. Rankin and S. Cradock, *Structural Methods in Inorganic Chemistry*, 1st Edn.(1987), Blackwell Scientific Publications, Oxford, London.
2. R. S. Drago, *Physical Methods in Chemistry*, International Edition (1992), Affiliated East-West Press, New Delhi.
3. R. S. Drago, *Physical Methods in Inorganic Chemistry*, 1st Edn.(1971), Affiliated East-West Press, New Delhi.
4. K. Nakamoto, *Infrared and Raman Spectra of Inorganic and Coordination Compounds*, 4th Edn. (1986), John Wiley & Sons, New York.
5. W. Kemp, *Organic Spectroscopy*, 3rd Edn. (1991), Macmillan, London.
6. G. Aruldhas, *Molecular Structure and spectroscopy*, Prentice Hall of India Pvt. Ltd., New Delhi (2001).

CHM403 (I): Inorganic Rings, Chains, and Clusters

Credits:3

1. **Isopoly and Heteropoly Acids and Salts:** Synthesis and structural principles with reference to those of V, Nb, Ta, Cr, Mo and W

2. **Metal Clusters and Metal-Metal Bonds:** Compounds with metal-metal multiple bonds, metal carbonyl, halide and chalcogenide clusters.

3. **Polyhedral Boranes:** Higher boranes, carboranes, metallo-boranes and metallo-carboranes –Structure and Bonding in the light of Wade's and Jemmis' Rules

4. **Parallels between main group and Organometallic Chemistry:** Isolobal concept (Hoffman) in organometallic and metal-cluster chemistry

5. **Inorganic Polymers:** Classification, Types of Inorganic Polymerization, Comparison with organic polymers, Boron-oxygen and boron-nitrogen polymers, silicones, coordination polymers, sulfur-nitrogen, sulfur-nitrogen-fluorine compounds, – binary and multi-component systems, hemolytic inorganic systems.

Books Recommended

1. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn. (1999), John-Wiley & Sons, New York.
2. James E. Huheey, *Inorganic Chemistry*, 4th Edn. (1993), Addison Wesley Pub. Co., New York
3. 3. N. N. Greenwood and A. Earnshaw, *Chemistry of the Elements*, 2nd Edn. (1997), Butterworth Heinemann, London.

CHM404 (I): Special Topics in Inorganic Chemistry

Credits:3

1. **Macrocyclic Complexes:** Types of macrocyclic ligands – design and synthesis by coordination template effect, di- & poly-nuclear macrocyclic complexes; applications of macrocyclic complexes.

2. **Supramolecular Chemistry:** Concept of supramolecular chemistry, nomenclature, molecular recognition, metallo-macrocylces as receptors, design of supramolecular through non-covalent interactions and their applications in transport processes

3. **Molecular Magnetic Materials:** Basic concepts of molecular magnetism, types of magnetic interactions, inorganic and organic ferro-magnetic materials, low-spin – high-spin transitions, isotropic interactions in Cu(II) dinuclear compounds, magnetic chain compounds, magnetic long-range ordering in molecular

compounds: molecular magnets, physical investigations and applications.

4. **Metallomesogens:** Basic concepts, types of meso-phases, synthetic strategies, characterization and applications.

Books Recommended

1. Jean-Marie Lehn, *Supramolecular Chemistry*, VCH, Weinheim (1995).
2. J. L. Serrano, *Metallomesogens*, VCH, Weinheim (1996).
3. Oliver Kahn, *Molecular Magnetism*, VCH, Weinheim (1993).
4. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann, *Advanced Inorganic Chemistry*, 6th Edn., John Wiley & Sons (Asia), Singapore (2003).

Organic Chemistry Specialization

CHM402 (O): Application of Spectroscopy to Structural Analysis

Credits:3

1. **Ultra-Violet Spectroscopy:** Absorption of dienes, polyenes, carbonyl compounds and α,β- unsaturated carbonyl compounds. Woodward rule and its application. Aromatic compounds.
2. **Infrared Spectroscopy:** Vibration modes and bond stretching. Absorption of common functional groups, electrical and steric effects, effects of Hydrogen bonding. Fingerprint region and interpretation of IR spectra.
3. **PMR Spectroscopy:** Interpretation of spectra, chemical shift, shielding mechanism and anisotropic effects, chemical exchange and chemical shifts in chiral molecules. Spin-spin interactions, naming spin systems, magnitude of coupling constant: Germinal, vicinal and long range couplings. Second order spectrum and analysis of AB, AMX and ABX systems. Simplification of Complicated Spectra: Aromatic induced shifts spin decoupling, deuterium exchange, spectra at higher fields. Hindered rotation and rate processes.
4. **CMR Spectroscopy:** General considerations, chemical shift, coupling constants. Nuclear Overhauser effect. Spin-spin, spin-lattice relaxations. Off resonance decoupling. DEPT. Interpretation of simple CMR spectra. 2 DNMR: COSY, NOESY and HETCOR
5. **Mass Spectrometry :** Introduction, ion production, fragmentation, factors influencing ion abundance, single and multiple bond cleavage, rearrangements, cleavage associated with common functional groups, molecular ion peak, metastable ion peak, Nitrogen rule and interpretation of mass spectra
6. **Problems:** Structure elucidation based on spectroscopic data.

Book Recommended

1. J.R.Dyer, *Application of Absorption Spectroscopy of Organic Compounds,* Prentice Hall, New Delhi (1978).
2. R.M. Silverstein and F.X. Webster, *Spectroscopic Identification of Organic Compounds*, 6th Edition (2003) John Wiley, New York.
3. D.H. Williams and I.F. Fleming, *Spectroscopic Methods in Organic Chemistry*, 4th Edition(1988), Tata-McGraw Hill, New Delhi.
4. P.Y Bruice, *Organic Chemistry*, 2nd Edition (1998) Prentice – Hall, New Delhi.

CHM403 (O): Reagents and Organic Synthesis

Credits:3

1. **Reduction :** (i) Complex metal hydride reductions: $LiAlH_4$ and $NaBH_4$; reduction of aldehydes and ketones, stereochemistry of ketone reduction, (ii) Reduction of conjugated systems: Birch reduction, (iii) Hydroboration (iv) Miscellaneous: Tributyltin hydride, Wilkinson's catalyst, Wolf Kishner reduction, Arene sulfonyl hydrazine

2. **Oxidation :** (i) Oxidation with peracids: Oxidation of carbon-carbon double bonds (Sharpless epoxidation), carbonyl compounds, allylic carbon-hydrogen bonds, (ii) Oxidation with selenium dioxide and Osmium tetraoxide, (iii) Woodward and Prevost hydroxylation (iv) Oxidation with lead tetraacetate, mercuric acetate

3. **Reagents and Reactions :** (i) Gilman's reagent – Lithium dimethylcuprate (ii) Lithium diisopropylamide (LDA) (iii) Dicyclohexyl carbodiimide (DDC) (iv) 1,3-Dithiane (Umpolung reagent) (v) Peterson's synthesis(vi) Bakers yeast (vii) DDQ (viii) Heck reaction (ix) Suzuki coupling/Sonogashira (x) Mukaiyama reaction

4. **Protecting groups:** Hydroxy, carbonyl and amines

Books Recommended

1. H.O. House, *Modern Synthetic Reactions*, 2nd Edition (1972), Benjamin/Cummings Publishing Company, California.
2. L.F. Fieser and M. Fieser, *Reagents for Organic Synthesis,* Vol. 1-16, Wiley-Interscience, New York.
3. M.B. Smith and J. March, *March's Advanced Organic Chemistry – Reactions, Mechanisms & Structure*, 5th ed. (2001), Wiley-Interscience, New York.
4. M. B. Smith, *Organic Synthesis,* McGraw Hill Inc., New York (1995).
5. 5. J. Clayden, N. Greeves, S. Warren, and E. Wothers, *Organic Chemistry,* Oxford Univ. Press, Oxford (2001).
6. 6. P. R. Jenkins, *Organometallic Reagents in Synthesis,* Oxford science Publ., Oxford (1992).

CHM404 (O): Heterocylces and Vitamins

Credits:3

1. **General Considerations**: The Disconnection approach and Retrosynthesis in reference to the heterocylces.

2. **The Chemistry** of the following ring systems: Synthesis and reactions including some given aspects.
   a. Three-membered rings --- Aziridines
   b. Four-membered rings --- Azetidines and their 2-oxo derivatives
   c. Condensed pyrroles ---- Indoles
   d. Five-membered rings containing two heteroatoms:
      (i) Oxazoles--- Reaction as dienes, Cornforth rearrangement, Reaction with singlet oxygen.
      (ii) Isoxazoles--- Boulton–Katritzky rearrangement, photoisomerizations.
      (iii) Pyrazoles --- Rearrangement to imidazoles
      (iv) Imidazoles --- Acidity of C-2 hydrogen, Catalyst for ester hydrolysis
      (v) Thiazoles- Thiazolium ylide as catalyst.
   e. Six-membered rings- Pyrimidines- ANRORC mechanism in Nucleophilic substitution.
   f. Purines- Structure and synthesis of Caffeine.

3. **Vitamins:** Structure determination including synthesis of

   (i) Thiamine (Vitamin B1)

   (ii) Pyridoxine (Vitamin B6)

   (iii) Biotin (Vitamin H)

Books Recommended

1. I.L. Finar, *Organic Chemistry*, Vol. II, 5th Edition (1975) Reprinted in 2004, Pearson Education Pvt. Ltd., New Delhi.
2. T.L. Gilchrist, *Heterocyclic Chemistry*, 3rd Edition (1997) Addison-Wesley Longman Ltd., England
3. R.K. Bansal, *Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms*, 3rd Edition (1999), New Age International, Publisher, New Delhi.
4. A.R. Katrizky and A.F.Pozharskii, *Handbook of Heterocyclic Chemistry*, 2nd Edition (2000), Pergamon Press, Oxford.
5. *Advances in Heterocyclic Chemistry*, A.R. Katritzky (Editor), Academic Press, New York.
6. *Heterocyclic Compounds*, A. Weissberger (Editor), Interscience, New York.
7. *Heterocyclic Chemistry, 3rd ed.* J.A. joule, K. Mills, G.F. Smith, Stanley Thornes(Publishers) Ltd. U.K. (1998), Indian Reprint 2004.
8. *Heterocyclic Chemistry Vol-I,II,III,* 1st ed. R.R. Gupta, M. Kumar, V. Gupta Springer-Verlag, Berlin Heidelberg Publication(2005)

Physical Chemistry Specialization

CHM402 (P): Statistical Mechanics

Credits:3

1. **Review of Basic Statistical Mechanics**: A Review of Thermodynamics. Phase space. Ensemble. Liouville theorem. Equal a priori probability. Microcanonical ensemble. Quantization of phase space. Entropy. Gibbs paradox. Entropy of a two level system. Canonical and grand canonical ensembles. Ideal gas in canonical and grand canonical ensembles.

2. **Partition Function:** Review of rotational, vibrational and translational partition functions. Application of partition functions to specific heat of solids and chemical equilibrium. Real gases.

3. **Bose-Einstein distribution:** Einstein condensation. Thermodynamic properties of ideal BE gas.

4. **Fermi-Dirac distribution:** Degenerate Fermi gas. Electron in metals. Magnetic susceptibility.

5. **Fluctuations*:*** Mean square deviation and fluctuation in ensembles. Concentration fluctuation in quantum statistics.

6. **Non-equilibrium states*:*** Boltzmann transport equation. Particle diffusion. Electrical conductivity

Books Recommended

1. *Statistical Mechanics*, B.K. Agarwal and M. Eisner, Wiley Eastern, New Delhi (1988).
2. *Statistical Mechanics*, D.A. Mcquarrie, Harper and Row Publishers, New York (1976).

CHM403 (P): Solid State Chemistry

Credits:3

1. **Solid State Reactions:** General Principles, Experimental procedure, Co-precipitation as precursor to solid-state reactions, Kinetics of solid-state reactions, Crystallization of solutions, melts, glasses and gels. Growth of single crystals: Czochralski, Bridgman and Stockbarger methods. Zone Melting.

2. **X-ray Diffraction & Crystal Structure:** Diffraction of X-rays by crystals: The Laue equations and Bragg's law, Definitions related to crystal structure, crystallographic direction and crystallographic phases. X-ray diffraction experiments: The powder method and the single crystal method. Reciprocal lattice. Structure factor and its relation to intensity and Electron density. The phase problem. Description of procedure for an X-ray structure analysis

3. **Phase Transitions:** Thermodynamic and Burger's classification of phase transition, Kinetics of phase transition- nucleation and growth, T-T-T diagrams, Factors influencing kinetics of phase transition, Martensitic and order-disorder transitions.

4. **Electronic Properties and Band Theory:** Electronic structure of solids- band theory, Refinement of simple band theory- k-space and Brillouin Zones, Band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, Doped semiconductors, p-n junctions. Superconductors Meissner effects, Basic concepts of BCH theory, Josephson devices.

5. **Magnetic Properties:** Classification of solid materials: Quantum theory of paramagnetics. Cooperative phenomena. Magnetic domains. Hysteresis.

Books Recommended

1. A.R. West, *Solid State Chemistry and its Applications*, John Wiley and Sons, Singapore (1984).
2. L.V. Azaroff, *Introduction to Solids,* Tata McGraw-Hill, New Delhi (1977).
3. L. Smart and E Moore, Solid State Chemistry, Chapman & Hall, Madras (1992).
4. H. V. Keer, Principles of Solid State, Wiley Eastern (1993)

CHM: 404(P): Chemical Kinetics

Credits:3

1. **Experimental Techniques for Fast Reaction:** Flow techniques, relaxation methods, flash photolysis.

2. **Transition State Theory:** Application of statistical mechanics to transition state theory, Comparison of transition state theory with experimental results. Thermodynamic treatment of TST. Theories of unimolecular reactions--treatments of Lindmann, Hinshelwood, Rice-Ramsperger- Kassel (RRK), and Rice- Ramsperger-Kassel-Marcus (RRKM).

3. **Reactions in Solution:** Reaction between ions; Effect of solvent (single & double sphere models), interpretation of frequency factor and entropy of activation, influence of ionic strength, salt effect and reaction mechanisms, Reactions involving dipoles. Influence of pressure on reaction rates in solution. Significance of value of activation parameters. Influence of substituents on reaction rates Electronic theories of organic reactivity. Linear free energy relationships, The Hammett equation, significance of σ and ρ. The Taft equation.

4. **Homogeneous Catalysis:** General catalytic mechanism, Mechanism of acid-base catalysis (protolytic and prototropic). Bronsted catalytic law.

5. **Molecular collisions:** Intermolecular potential and centrifugal barrier, impact parameter, collision cross section and rate, energy threshold, opacity function and reaction cross-section.

   Experimental probes of reactive collisions: IR Chemiluminescence, Laser-induced Fluorescence.

   PES: Features of potential energy surfaces (PES), Enhancement of reaction.

   Molecular Beams: Stripping and rebound mechanism.

   Dynamics with Femtosecond laser techniques: Detection of activated complex.

Books Recommended

1. M. J. Pilling and A.P.W, Seakins, *Reaction Kinetics*, Oxford Science Publication, New York (1998).
2. K.J. Laidler, *Chemical Kinetics*, 3rd Edition (1967), Harper & Row Publishers, New York.
3. J. Rajaram and J.C. Kuriacose, *Kinetics and Mechanism of Chemical Transformation*, Ist Edition (1993), MacMillan India Ltd., New Delhi.
4. B. G. Cox, *Modern Liquid Phase Kinetics*, Oxford University Press, Oxford (1994).
5. R. D. Levine and R. B. Bernstein, *Molecular Reaction Dynamics and Chemical Reactivity*, Oxford University Press, Oxford (1987).
6. A. H. Zewail, *Femtochemistry-Ultrafast Dynamics of the Chemical Bond*,Vols. I and II, World Scientific, New Jersey, Singapore (1994).

CHM405: Projects

Credits : 5

Elective Papers

Elective-II (Group-B)

CHM406: Environmental Chemistry

Credits:3

1. **Introduction to Environmental Chemistry:** Concept and scope of environmental chemistry, Environmental terminology and nomenclatures, Environmental segments, The natural cycles of environment (Hydrological, Oxygen, Nitrogen, Phosphorous and Sulphur cycles).

2. **Atmosphere:** Regions of the atmosphere, Reactions in atmospheric chemistry, Earth's radiation balance, Particles, ion and radicals in the atmosphere, stratospheric chemistry: The chemistry of ozone layer, The role of chemicals in ozone destruction, The green-house effect and Global warming, El-Nino phenomenon

3. **Hydrosphere:** Complexation in natural water and waste-water, Micro-organism in aquatic chemical reactions, Eutrophication, Re-cycle of waste-water in process industry, Treatment of sewage and reuse of water in industry and agriculture, Microbiology mediated redox reactions and Nitrogen transformation by bacteria.

4. **Lithosphere:** The terrestrial environment, Soil formations, Soil properties (physical/chemical), inorganic and organic components in soil, acid-base and ion-exchange reactions in soil, micro and macro nutrients, nitrogen pathways and NPK in soil, waste and pollutants in soil, waste classification and disposal.

5. **Chemical Toxicology:** Toxic chemicals in the environments, Impact of toxic chemicals on enzymes, Biochemical effects of arsenic, cadmium, lead, mercury, carbon monooxide, nitrogen oxides, sulphur oxides, ozone, PAN, cyanide, pesticides, insecticides and carcinogens

6. **Air Pollution:** Air pollutants (sources, classification, sampling and monitoring): Particulates, Aerosols, SOx, NOx, COx and hydrocarbon emission, Photochemical smog, Autoexhausts, Acidrains, Air-quality standards

7. **Water Pollution:** Water pollutants (sources, sampling and monitoring), Water-quality parameters and standards: physical and chemical parameters (colour, odour, taste and turbidity), Dissolved oxygen, BOD, COD, Total organic carbon, Total nitrogen, Total sulfur, Total phosphorus and Chlorine, Chemical speciation

8. **Environmental Management:** Methods of environmental management, Radioactive waste management, Environmental impact assessment, Natural resources of energy-consumptions and conservation.

Books Recommended

1. G.W. Vanloon, S.J. Duffer*, Environmental Chemistry - A Global Perspective*, Oxford University Press (2000).
2. F.W. Fifield and W.P.J. Hairens, *Environmental Analytical Chemistry*, 2nd Edition (2000), Black Well Science Ltd.
3. Colin Baird*, Environmental Chemistry*, W.H. Freeman and Company, New York (1995).
4. A.K. De, *Environmental Chemistry*, 4th Edition (2000), New Age International Private Ltd.,New Delhi.

Additional References

1. Peter O. Warner, *Analysis of Air Pollutants,* 1st Edition (1996), John Wiley, New York.

2. S.M. Khopkar, *Environmental Pollution Analysis,* 1st Edition (1993), Wiley Estern Ltd., New Delhi.

3. S.K. Banerji, *Environmental Chemistry,* 1st Edition (1993), Prentice-Hall of India, New Delhi.

CHM407: Photo Inorganic Chemistry

Credits:3

1. **Basic Principles**: Photochemical laws – Franck-Condon principle, radiative lifetimes, quantum yields, Excimers and Exciplexes, Reactions of Excited States, Energy Transfer, Electron Transfer and Atom Transfer quenching rates and mechanisms

2. **Photochemistry of Transition Metal Complexes**: Photoreactions of complexes of Cr(III) and Co(III), photo-aquation, photo-substitution and photo-racemization Photochemistry of $Ru(bpy)_3^{2+}$ and its application as photocatalyst for photsplitting of water, photo-oxidation of 2-propanol and photoreduction of carbondioxide, cyanide bridged triruthenium(II) bipy complexes as antenna. Photochemistry of diisocyanide bridged diimers of Rh(I). Applications of quenching and sensitization techniques in the identification of reactive state in oordination complexes

3. Photochemistry of Transition Metal Carbonyls and other organometallic compounds

4. Photochemistry of Europium, Cerium and Uranyl ions.

Books Recommended

1. D. M. Roundhill, *Photochemistry and Photophysics of Metal Complexes*, Plenum Press, New York and London (1994).
2. G. J. Ferraudi, *Elements of Inorganic Photochemistry*, John Wiley & Sons (1988).
3. V. Balzani and V. Carassiti, Photochemistry of Coordination Compounds, Academic Press, London (1970).
4. O. Horvath and K.L. Stevenson, *Charge Transfer Photochemistry of Coordination Complexes*, VCH Publishers Inc. (1993)

CHM408 Bio-Organic Chemistry

Credits:3

1. **Emzymes and Mechanism of Enzyme Action**: Classification, isolation and purification. Kinetics of enzyme action-Michaelis-Menten equation.Two substrate reactions. Enzyme inhibition. Mechanism of action of chymotrypsin , aldolase , alcohol dehydrogenase , lysozyme

2. **Co-enzyme Chemistry**: Cofactors as derived from vitamins, co-enzymes, prosthetic groups and apoenzymes. Structure and biological functions of coenzyme A , thiamine pyrophosphate , pyridoxal phosphate ,NAD^+ , $NADP^+$, FMN , FAD , lipoic acid and vitamin-B_{12} . Mechanisms of reactions catalysed by the above cofactors

3. **Nucleic Acids:** Retrosynthetic analysis of Nucleic Acids- Nucleotides, Nucleosides, Nucleobases (A,T,G,C and U), Sugars (Ribose and deoxyribose). Assembly of oligonucleotide chain: Synthesis of polymer support, Nucleosides and Nucleotides, solid phase synthesis of Oligonucleotides (DNA/RNA) through phosphoramidite and phosphorothionate approach. Application of protecting groups (-NH_2 and –OH functions, Base and Acid labile) and their deprotection and purification.Concept of depurination.

4. **Biosynthesis:** terpenoids - C_5, C_{10}, C_{15}, C_{20} units; alkaloids- quinine and morpholine, steroids- cholesterol.

5. **Molecular Recognition :** Fullerenes : as host as well as guest , enzyme modeling using an artificial host frame work , cyclodextrins as esterase mimics , functionalized cyclodextrins ; chiral corands.Drug design(enzymes as targeted for drug design).

Books Recommended

1. A.L. Lehninger, *Principles of Biochemistry,* (1992) CBS Publishers, Delhi.
2. D. Voet, J.G. Voet & CW Pratt, *Fundamentals of Biochemistry*, (1999) John Wiley & Sons, New York.
3. H.R. Mahler and E.H. Cordes, *Biological Chemistry*, 2nd Edition, (1971) Harper and Row Pub., New York.
4. T.C. Bruice and S. Bentkovic, *Bioorganic Mechanisms*, Vol. I & II, (1966) W. A. Benjamin, New York.
5. H. Dugas and C. Penney, *Bioorganic Chemistry: A Chemical Approach to Enzyme Action*, (1981) Springer- Verlag, New York.
6. C. Walsh, *Enzymatic Reaction Mechanisms*, W.H. Freeman & Co., New York.
7. Supramolecular Chemistry by Jonathan, W. Steed and Jerry L. Atwood, John Wiley & Sons Ltd. 2000.
8. Oligonucleotides and analogues: A Practical approach. F. Eckstein. IRL Press, Oxford.
9. Methods in Molecular Biology. Vol. 20. Sudhir Agrawal. Humana Press Totowa, New Jersey.
10. Oligonucleotide Synthesis. A Practical Approach. M. J. Gait. IRL Press, Oxford.

CHM409: Materials Chemistry

Credits:3

1. **Introduction:** Materials and their classification, Role of Chemistry in Material design.

2. **Synthesis and characterization of materials:** Preparative techniques: Ceramic methods; chemical strategies, chemical vapour deposition; preparation of nanomaterials, Langmuir-Blodgett Films. Fabrication of ordered nanostructures. Composition and purity of materials.

3. **High- Tc Oxide Superconductors:** Structural features of cuprate superconductors. 1-2-3 and 2-1-4 cuprates; structure. Normal state properties: anisotropy and temperature dependence of electrical resistance. Superconducting state: heat capacity, coherence length, relation between Tc and hole concentration in cuprates; mechanism of superconductivity in cuprates. Applications of high Tc-cuprates

4. **Organic Materials:** Conducting organics - Metals from molecules, charge transfer materials and conducting polymers. Organic superconductors. Fullerenes. Molecular ferromagnets and ferroelectrics. Liquid crystals: mesomorphic behaviour, optical properties of liquid crystals, display devices.

5. **Non-linear materials:** Second and third order non-linear effects; molecular rectifiers and frequency doublers; unimolecular electronic devices. Photochromic materials; optical datastorage, memory and switches.

Books recommended

1. A.R. West, *Solid State Chemistry and its Applications*, John Wiley & Sons, Singapore (1984)
2. C.N R. Rao and J. Gopalkrishnan, *New Directions in Solid State Chemistry*, Cambridge Univ. Press (1997).
3. T. V. Ramakrishnan and C.N. Rao, *Superconductivity Today,* Wiley Eastern Ltd., New Delhi (1992).
4. P. Ball, *Designing the Molecular World: Chemistry at the Frontier*, Princeton Univ. Press, (1994).

CHM410: Laboratory work for Computer Applications in Chemistry (Common to all branches)

Credits:2

Computer programming based on FORTRAN-77 and Numerical methods as per the details of the paper CHM – 401 (Computer Applications in Chemistry). Exposure to available standard application packages like: Chemdraw, generation of graphs, data sheets creation, and tables using Excel Programme.

M.Sc. COMPUTER SCIENCE
Department of Computer Science
Banaras Hindu University

Semester-wise Distribution of Courses and Credits

SEMESTER I		
Course No.	***Course Title***	***Credits***
CSM101	Design Methods and Analysis of Algorithms	4
CSM102	Object Oriented Programming through JAVA	4
CSM103	Data Communication and Computer Networks	4
CSM104M	*Minor Elective*: Theory of Computation (only for Computer Science and Computer Application students)	3
CSM105	*Lab. Exercises based on course CSM101*	3
CSM106	*Lab. Exercises based on course CSM102*	3
	Total	**21**
SEMESTER II		
CSM201	Compiler Design	4
CSM202	Computer Graphics	4
CSM203	Artificial Intelligence	4
CSM204	Software Engineering	4
CSM205	Technical Writing and Research Seminar	2
CSM206M	*Minor Elective*: E-commerce (only for Computer Science and Computer Application students)	3
CSM207	*Lab. Exercises based on course CSM201*	3
CSM208	*Lab. Exercises based on course CSM202*	3
	Total	**27**
M.Sc. SEMESTER III		
CSM301	Parallel Computing	4
CSM302	Internals of UNIX OS and Network Programming	4
CSM303(A-I)	Major Elective Course I: Any one of the following CSM303A: Advanced Computer Architecture CSM303B: Soft Computing Techniques CSM303C: Information Retrieval and Web Mining CSM303D: Distributed Systems CSM303E: Science of Programming CSM303F: Advanced DBMS CSM303G: Quantum Computing CSM303H: Introduction to Cryptography CSM303I: Advanced course in Software Engineering	4
CSM304M CSM305M CSM306M	*Minor Elective*: Any one of the following (only for Computer Science and Computer Application students) Bioinformatics Algorithms Simulation and Modeling Operation Research	3
CSM307	*Lab. Exercises based on course CSM301*	3
CSM308	*Lab. Exercises based on course CSM302*	3
	Total	**21**
M.Sc. SEMESTER IV		
CSM401	Dissertation	18
CSM402	Comprehensive Viva	7
	Total	**25**
	Grand Total	**94**

SEMESTER I

CSM101	Design Methods and Analysis of Algorithms	Credits: 4

Elementary Data Structures, Basic Computational Models.

Simple Algorithms. Analyzing Algorithms, Asymptotic Notation, Recurrence relations.

Design Methods : General Consideration, Algorithm design paradigms and representative problems: Divide and Conquer (Binary search, Merge Sort, Quick Sort, Arithmetic with Large integers, etc.), Greedy Method (Minimal Spanning Tree, Shortest Paths, Knapsack, etc.), Dynamic Programming (Chained Matrix Multiplication, Optimal Storage on Tapes, Shortest Paths, Optimal Search Trees, etc.), Backtracking (8-queens problem, Graph Colouring, Hamiltonian Cycles, etc.), Branch and Bound (0/1 Knapsack problem, Travelling Salesperson, etc.), Approximation (Graph Colouring, Task Scheduling, Bin Packing, etc.), Probabilistic Algorithms (Numerical Integration, Primality Testing, etc.).

Graph Algorithms: BFS, DFS and its applications.

Polynomial Evaluation and Interpolation, Fast Fourier transforms.
Intractable Problems : Basic Concepts, Nondeterministic Algorithms, NP Completeness, Cook's Theorem, Examples of NP-Hard and NP-Complete problems. Problem Reduction.

Lower Bound Techniques: Comparison tree, Reduction, Adversary argument.

Suggested Readings:

1. A.Aho, V. Alfred, J. Hopcroft and J. D. Ullman, The Design and Analysis of Computer Algorithms, Addison Wesley.
2. E. Horowitz and S. Sahani, Fundamentals of Computer Algorithms, Galgotia, New Delhi.
3. S.E. Goodman and S.T. Hedetniemi, Introduction to the Design and Analysis of Algorithms, McGraw Hill.
4. G. Brassard and P. Bratley, Algorithmics, PHI.
5. S. K. Basu, Design Methods and Analysis of Algorithms, PHI, 2005.
6. Anany V. Levitin, Introduction to the Design & Analysis of Algorithms, Addison Wesley

CSM102	Object Oriented Programming through JAVA	Credits: 4

Object Oriented Analysis and Design Concepts: Object Modeling Technique; General Concepts: Object, Class, Data Abstraction and Encapsulation, Inheritance, Polymorphism, Dynamic Binding, Message Passing; Benefits of OOP, Object-oriented Languages.

Object oriented Programming using JAVA:
Language Basics- Variables Primitive Data Types Operators Expressions, Statements, and Blocks Control Flow Statements Arrays, Classes and Objects, Constructors and Destructors, Operator Overloading, Type Conversions, Inheritance, Interfaces, Packages, Threads, Exception handling, colors, fonts and graphics, Applets, working with input/output

Suggested Readings:

1. Rodgers Cadenhead, Laura Lemay, Sams Teach Yourself Java 2 in 21 Days, Sams Publishing.
2. E. Balagurusamy, Programming with Java, Tata McGraw Hill.
3. Bruce Eckel, Thinking in Java, Pearson Education.
4. Peter Van Der Linden, Just Java 2, Sun Microsystems/Prentice Hall.

CSM103	Data Communication and Computer Networks	Credits: 4

Introduction, Networks models – OSI model, Internet model.

Physical layer : Signals - Analog, Digital, Digital transmission - Coding, Sampling, Analog Transmission - Modulation of Digital and analog signals, Multiplexing, Switching, Transmission Media.

Data link layer : Error detection and Correction, Data link control and protocol, Point to point access, Multiple access , LANS- Traditional Ethernet, Fast Ethernet, Gigabit Ethernet, Wireless LAN's - IEEE 802.11, Blue tooth, Connecting LANs - Connecting devices, Satellite networks.

Network layer : Internetworking, Addressing, Routing, Networks layer protocols – ARP , IP, ICMP, Ipv6, Routing- Introduction, Routing Algorithms & Protocols.

Transport layer : UDP, TCP, Congestion and Control, Quality of service (QOS) and techniques to improve QOS.

Application layer : DNS, Electronic mail, SMTP, File transfer, FTP, HTTP, World wide web, Network Security, Network Management Protocol.

Suggested Readings:

1. W.Stallings, Data and Computer Communication, McMillan.
2. A.S.Tanenbaum, Computer Networks, PHI.
3. J. Martin, Computer Network and Distributed Data Processing, Prentice Hall.
4. W.Stallings, Local Networks, McMillan.
5. M.Schwertz, Computer Communication Network Design and Analysis, Prentice Hall.
6. B. A. Forouzan, Data Communications and Networking, TMH, 2003.
7. Keshav, An Engineering Approach to Computer Networks, Addison-Wisley.
8. Peterson and Davie, Computer Networks, Morgan and Kaufmann, 2000.

CSM104M	*Minor Elective*: Theory of Computation (only for computer science and computer application students)	Credits: 3

A brief review of Finite Automata, Regular expressions, Regular languages, Deterministic and non-deterministic computations. Pumping Lemma for Regular languages, Context free languages, Pushdown automaton, Pumping Lemma for Context free languages, Grammar types and Chomsky Hierarchy. Turing Machines (TM), Variations of TM's, Universal Turing Machines (UTM), Church-Turing Thesis, Relation of Languages to Automata. Turing computable functions, Halting problem, Solvability, Undecidability and Computability.

Suggested Readings:

1. J.E.Hopcraft, R. Motwani and J.D. Ullman, "Introduction to Automata Theory, Languages and Computation", Pearson Education
2. Cohen, "Introduction to Computer Theory", John Wiley.
3. M. Sipser, Introduction to Theory of Computation, PWS Publishing Corporation, 1997.
4. J.E. Hopcroft, J.D. Ullman, Introduction to Automata Theory, Languages and Computation, Addison-Wisley.
5. T.C. Martin, Theory of Computation, Tata McGraw-Hill
6. H.R. Lewis, C.H. Papadimitrou, Elements of the Theory of Computation, PHI.

CSM105	*Lab. Exercises based on course CSM101*	Credits: 3

This paper consists of programming exercises based on course CSM101: Design Methods and Analysis of Algorithms.

CSM106	*Lab. Exercises based on course CSM102*	Credits: 3

This paper consists of programming exercises based on course CSM102: Object Oriented Programming through JAVA.

SEMESTER II

CSM201	Compiler Design	Credits: 4

Compilers and Translators, Syntactic and lexical structure of a language.
Finite Automata and design of lexical analyzer, Context free grammars and derivation of parse trees, basic parsing techniques: shift-reduce, operator-precedence, top-down, predictive. Disambiguation of grammar.
Automatic construction of efficient parsers: LR parser, construction of parsing tables. Syntax Directed Translation, L-attributed and S-attributed Definitions.
Code Generation and Code Improvement.
Symbol table organization, Run time storage management, Error detection and recovery.

Suggested Readings:

1. Aho, Ullman and Sethi, Principles of Compiler Design, Addison Wesley.
2. J. P. Trembley and P. G. Sorensen, The Theory and Practice of Compiler Writing, McGraw Hill.
3. Holub, Compiler Design in C, PHI.

CSM202	Computer Graphics	Credits: 4

Introduction to Computer Graphics, Display Technologies, Random and Raster Scan, frame buffer, bit plane, Input Devices, Graphics Standards, Graphics Hardware.
Line and Circle Drawing Algorithms, Scan Conversion, filling algorithms, clipping, Two and Three Dimensional transformations, Homogeneous Coordinates, Rigid Body and Affine transformations, Parallel and perspective projections, vanishing points, viewing transformation, Hidden line removal method, Curve and Surface: Cubic Spline, Bezier curve, B-Spline Curves, Parametric Surface, Surface of revolution, Sweep surface, Fractal Curves and surfaces.

Suggested Readings:

1. Computer Graphics (Principles and Practice) by Foley, van Dam, Feiner and Hughes, Addisen Wesley (Indian Edition)
2. Computer Graphics by D Hearn and P M Baker, Printice Hall of India (Indian Edition).
3. Mathematical Elements for Computer Graphics by D F Rogers

CSM203	Artificial Intelligence	Credits: 4

Introduction: Definitions and approaches, Foundations of A.I., History of AI, Areas and state of the art in A.I., A.I. Programming languages, Concept of Intelligent Agents.
Problem Solving: Problem solving as state space search, production system, control strategies and problem characteristics; Search techniques: Breadth First and Depth-first, Hill-climbing, Heuristics, Best-First Search, A* algorithm, Problem reduction and AO* algorithm, Constraints satisfaction, Means Ends Analysis, Game Playing.
Knowledge Representation and Reasoning: Syntactic and Semantic representations, Predicate and prepositional logic, Resolution, Unification, Deduction and theorem proving, Question answering; Forward versus backward reasoning, Matching, Indexing;
Ontological Engineering, Formal Theory of Beliefs, Semantic Net, Frames, Conceptual Dependencies and Scripts, Truth Maintenance Systems.
Selected Topics and Applications: Philosophical issues, Introduction to Natural Language Processing, Expert Systems and Multiagent Systems.

Suggested Readings:

1. S. Russel, P. Norvig, Artificial Intelligence: A Modern Approach, Pearson Education.
2. E. Rich and K. Knight, Artificial Intelligence, Tata McGraw Hill.
3. N.J. Nilsson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann.

CSM204	Software Engineering	Credits: 4

Introduction to Software Engineering: Definition; Software development and life-cycle models, CMM, Software Quality, role of metrics and measurement.
Requirements Analysis and Specification: SRS Building Process, Specification Languages, Validation of SRS, metrics, monitoring and control, Object Oriented analysis.
Software Project Planning: Software Cost Estimation Techniques, Project Scheduling & Tracking, Project Team Standards, software configuration management, management.
Software Design and Implementation: Design Concepts and Notations, Functional & Object Oriented Design Concepts, Design Strategies, Design specification and verification, Metrics, Design Translation Process.
Testing Strategies & Techniques, Debugging, Software Maintenance,
Metrics and Models: Design Metrics, Complexity Metrics, Software Reliability and Availability Models, etc. Software Reengineering, Cleanroom Approach, Software Reuse.
Introduction to IEEE Standards, Case Studies.

Suggested Readings:

1. "An Integrated Approach to Software Engineering", Pankaj Jalote, IIIrd Edition, Narosa Publishing House.
2. "Software Engineering: Principles and Practices", Waman S. Jawadekar, Tata McGraw-Hill.

3. "Software Engineering: A Practitioner's approach", Roger S. Pressman, McGraw-Hill.
4. "Software Engineering:, Ian Sommerville, Pearson Education.
5. "Fundamentals of Software Engineering", Carlo Ghezzi, Mehdi Jazayeri, Dino Mandrioli, PHI.
6. S. L. Pfleeger, Software Engineering: Theory and Practice, Pearson Education.

CSM205	Technical Writing and Research Seminar	Credits: 2

Students will be required to write a Paper on a topic approved by the department and to give a presentation based on it.

CSM206M	*Minor Elective*: E-commerce (only for computer science and computer application students)	Credits: 3

Introduction, Definition, Objectives, Advantages and disadvantages, Forces driving E-Commerce, Traditional commerce Vs. E-Commerce, E-Commerce opportunities for industries, Growth of E-Commerce.
E-Commerce Models: Business to consumer, Business to Business, Consumer to Consumer, other models – Brokerage Model, Aggregator Model, Info-mediary Model, Community Model and value chain Model.
Electronic Payment Systems: Special features required in payment systems, Types of E-payment systems, E-Cash, E-cheque, credit card, Smart Card, Electronic Purses.
E-Marketing, E-Customer Relationship Management, E-Supply Chain Management.
Security Issues in E-Commerce: Security risk of E-Commerce, Types of threats, Security tools and risk management approach. Cyber laws, Business Ethics, IT Acts.

Suggested Readings:

1. Bharat Bhaskar, Electronic Commerce – Frameroork Technologies and Applications, Tata McGraw Hill.
2. Ravi Kalakota & A.B. Whinston, Frontiers of Electronic Commerce, Pearson Education.
3. Ravi Kalakota & A.B. Whinston, Electronic Commerce – A Manager's Guide, Pearson Education.
4. Agarwala Kamlesh, N and Agarwala Deeksha, Business on the Net_Introduction to the E-Com., Macmillan India.
5. P. T. Joseph, E-Commerce: A Managerial Perspective, PHI, 2002.

CSM-207	*Lab. Exercises based on course CSM201*	Credits: 3

This paper consists of programming exercises based on course CSM201: Compiler Design.

CSM-208	*Lab. Exercises based on course CSM202*	Credits: 3

This paper consists of programming exercises based on course CSM202: Computer Graphics.

SEMESTER III

CSM301	Parallel Computing	Credits: 4

Introduction to Parallel Computing: Supercomputers and grand challenge problems, Modern Parallel Computers, Data Dependence Graph, Data Parallelism, Functional Parallelism, Pipelining and Data Clustering.
Interconnection Networks: Switch Network Topologies, Direct and Indirect Network Topology, Bus, Star, Ring, Mesh, Tree, Binary Tree Network, Hyper Tree Network, Hybrid, Hypercube, Perfect Shuffle Network, Torus and Butterfly Network.
Performance Analysis: Introduction, Execution Time, Speedup, Linear and Superlinear Speedup, Efficacy and Efficiency, Amdahl's Law and Amdahl Effect, Gustafson-Barsis's Law, Minsky's Conjecture, The Karp-Flatt Metric, The Isoefficiency Metric, Isoefficiency Relation, Cost and Scalability.
Parallel Computational Models: Flynn's Taxonomy, PRAM, EREW, CREW, ERCW, CRCW, Simulating CRCW, CREW & EREW, PRAM algorithms.
Introduction to Parallel Algorithms: Parallel Programming Models, PVM, MPI Paradigms, Parallel Programming Language, Brent's Theorem, Simple parallel programs in MPI environments, Parallel algorithms on network, Addition of Matrices, Multiplication of Matrices.

Suggested Readings:

1. Hwang and Briggs, Computer Architecture and Parallel Processing, McGraw Hill.
2. Crichlow, Introduction to Distributed and Parallel Computing, PHI.
3. M.J.Quinn, Designing Efficient Algorithms for Parallel Computers, McGraw-Hill.
4. V.Rajaraman, Elements of Parallel Computing, Prentice-Hall of India.
5. Joseph JA JA, Introduction to Parallel Algorithms, Addison Wesley.
6. S.G.Akl, The Design and Analysis of Parallel Algorithms, PHI.
7. Shashi Kumar M et al. Introduction to Parallel Processing, PHI New Delhi.

CSM302	Internals of UNIX OS and Network Programming	Credits: 4

The general overview, Unix Kernel, Internal representation of files, Buffering, System calls, Process structure and control, Process scheduling, memory management, I/O subsystem, Shell Programming , IPC, Distributed UNIX systems.
The UNIX model, Inter-process communication,, Communication protocols, Berkeley sockets, Transport layer interface, Library and other routines, Security issues, FTP, Line printer spoolers, Remote login, remote execution, Remote procedure calls, Remote drive access.

Suggested Readings:

1. R. Thomas and J. Yates, A User Guide to The UNIX System, Osborne McGraw-Hill.
2. M. J. Bach, The Design of Unix Operating System, PHI, 1996.
3. B. W. Kernighan and R. Pike, The UNIX Programming Environment, PHI, 1996.
4. W.R. Stevens, UNIX Network Programming, PHI, 1997.
5. Barry Nance, Network Programming in C, PHI, 1990.

CSM303A	Advanced Computer Architecture	Credits: 4

Architectural Abstraction, Classification schemes, Parallelism: Pipelining, Multiprocessing. Issues in Branch performance, Synchronization in Multiprocessing, High Performance Processor Design Issues: Pipeline design, Memory system design, I/O design.
Instruction level parallelism, Thread and process level parallelism, Data parallelism.
Vector machines, Dependency Analysis, Vectorization, Optimization in Vector Processing, Vector Chaining , Example systems. Associative Processors and Algorithms
Super-scalar and VLIW processors, Example systems and main issues in design.
Multiprocessors: Shared Memory, Distributed Memory Architectures; Multiprocessor Interconnections, Memory systems for Multiprocessors, Example systems; Cache Memory, coherence issues, protocols.
Multiprocessor Simulation and Measurement.

Suggested Readings:

1. D. Sima, T. Fountain, P. Kacsuk, "Advanced Computer Architectures: A Design Space Approach", Addison Wesley, 1997.
2. .J. Flynn, "Computer Architecture: Pipelined and Parallel Processor Design", Narosa Publishing House/ Jones
3. K. Hwang, “Advanced Computer Architecture: Parallelism, Scalability, Programmability”, McGraw-Hill, Inc
4. Hwang and Briggs, “Computer Architecture and Parallel Processing, McGraw Hill.
5. B. Barnes, Modeling and Performance Measurement of Computer Systems, MIT Press.

CSM303B	Soft Computing Techniques	Credits: 4

Introduction to Genetic Algorithm, Genetic Operators and Parameters, Genetic Algorithms in Problem Solving, Theoretical Foundations of Genetic Algorithms, Implementation Issues.

Neural Model and Network Architectures, Perceptron Learning, Supervised Hebbian Learning, Backpropagation, Associative Learning, Competitive Networks, Hopfield Network, Computing with Neural Nets and applications of Neural Network.

Introduction to Fuzzy Sets, Operations on Fuzzy sets, Fuzzy Relations, Fuzzy Measures, Applications of Fuzzy Set Theory to different branches of Science and Engineering.

Suggested Readings:

1. M. Mitchell, An Introduction to Genetic Algorithms, Prentice-Hall.
2. D. E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley.
3. Z. Michalewicz, Genetic Algorithms+ Data Structures = Evolution Programs, Springer-Verlag.
4. N.K. Sinha & M. M. Gupta(Eds), Soft Computing & Intelligent Systems: Theory & Applications, Academic Press, 2000.
5. M.T. Hagan, H. B. Demuth, And M. Beale, Neural Network Design, Thompson Learning, 1996.
6. C. Lau (Ed), Neural Networks, IEEE Press.
7. J. Freeman and D. Skapura, Neural Networks: Algorithms, Applications, and Programming Techniques, Addison-Wesley.
8. G. J. Klir and T. A. Folger, Fuzzy Sets, Uncertainty, and Information, PHI.
9. G. J. Klir, and B. Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice-Hall, 1995.
10. H. J. Zimmerman, Fuzzy Set Theory and Its Applications, Kluwer Academic Press.

CSM303C	Information Retrieval and Web Mining	Credits: 4

Information Retrieval Concepts and Models, Introduction to World Wide Web, Hypertext Data, Search Engines, Crawling the Web.
Indexing and Search: Boolean Queries and Inverted Index, Relevance ranking, Similarity search, Web directories, Combining Searching with Browsing, Metasearchers, Web Query Languages, Dynamic Search and Software Agents.
Clustering and Classification, Social network analysis, Measuring and Modeling the Web, Question answering, Semantic Web.

Suggested Readings:

1. Baeza-Yates, R. and Ribeiro-Neto, B., Modern Information Retrieval. Pearson Education 1999.
2. Chakrabarti, S., Mining the Web, Morgan Kaufmann (An Imprint of Elsevier) 2005.
3. Grossman, D. A. and Frieder, O., Information Retrieval: Algorithms and Heuristics. Kluwer 1998.

CSM303D	Distributed Systems	Credits: 4

Distributed Systems, Communication in distributed systems, processes and processors in distributed systems. Threads, systems Models, Process allocation, scheduling in distributed systems, fault tolerance, real-time distributed systems.
Theoretical issues in distributed systems: Logical clock, mutual exclusion, deadlock detection, agreement protocols, resource security and protection, concurrency control.
Distributed File System: Design and implementation, trends.
Distributed shared Memory, consistency models, page-based distributed shared memory, shared variable distributed shared memory, object-based distributed shared memory.
Multiprocessor OS, Database OS: General features and theoretical issues.
Case Studies: Amoeba, Mach, chorus, DCE, etc.
Multimedia Operating Systems: Process scheduling, File system, caching, Disk scheduling for multimedia.

Suggested Readings:

1. A.S. Tanenbaum, Distributed Operating System, Prentice-Hall, 1995.
2. A.S. Tanenbaum, Modern Operating Systems, Pearson Education Asia, 2001.
3. M. Singhal and N. G. Shivaratri, , Advance Concepts in Operating Systems, McGraw-Hill, 1994.
4. J. W. S. Liu, Real-Time Systems, Pearson Education, 2000.

CSM303E	Science of Programming	Credits: 4

Propositions, Precedence rules for operators, Tautologies, Propositions as set of states, Equivalence Transformations, Deductive proofs, Reference Rules, Proofs and Sub-proofs
Quantification, Free and bound variables, Substitution, Assertions, Proof Outlines, Language Semantics of a Simple Language, Programming as a Goal-Oriented Activity, Loop Invariants, Developing invariants, Efficiency Considerations, Bound Function, Program Inversion.

Suggested Readings:

1. David Gries, The Science of Programming, Narosa Publishing House, New Delhi.
2. Zohar Manna, Mathematical Theory of Computation, McGraw-Hill.
3. R. G. Stone, D. J. Cooke, Program Construction, Cambridge University Press.
4. E. W. Dijkstra, A Discipline of Programming, PHI.

CSM303F	Advanced DBMS	Credits: 4

Design Theory for Relational Database: Functional Dependencies, Decomposition of Relation schemes, Normal Forms for Relations. Schemes, Multivalued and other kinds of Dependencies.
Query Optimization: Basic Optimization Strategies, Algebraic Manipulation, Optimization of Selections in System, Exact Optimization for a Subset of Relational Queries, Optimization under Weak Equivalence.
Database Protection: Integrity, Constraints in Query-by-Example, Security, Security in query-by-Example, Security in Statistical Databases.
Concurrent Operations on the Database: Basic Concepts, A simple Transaction Model, Model with Read- and Write-Locks, Read-only, Write-only Model, Concurrency for Hierarchically Structured Items, Protection against Crashes, Optimistic Concurrency Control.
Principles of Distributed Data Bases, Framework for distribution. Translation of global queries into fragment queries. Query optimization and management of distributed transaction. Concurrency control and reliability in distributed databases.
Administration of Distributed Data Bases. Example Systems.

Suggested Readings:

1. J.D.Ullman, Principles of Database Systems, Galgotia, New Delhi.
2. S.Ceri, G. Relagatti, Distributed Databases, McGraw-Hill.
3. C. Papadimitriou, The Theory of Database concurrency Control, Computer Science Press.
4. T. Ozsu, P. Valduriez, Principles of Distributed Database Systems, Prentice-Hall.

CSM303G	Quantum Computing	Credits: 4

Introduction to Quantum Computing, Moore's Law, Limits from Bits to Qubits, Powers of Quantum Computing-Some Algorithms and Applications.
Qubits, Quantum Mechanics and Computer Science Perspectives. Quantum Gates, Applications of Quantum Computing, Shor's Algorithm and Quantum Fourier Transform, Quantum Search Algorithms, Physical Realization of Quantum Computers.

Suggested Readings:

1. Colin P. Williams, Scott H. Clearwater, Explorations in Quantum Computing, Springer.
2. Michael A. Nielsen, Isaac L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press.
3. Cris Calude, Gheorghe Paun, Computing with Cells and Atoms: An Introduction to Quantum, DNA and Membrane Computing, CRC.
4. Mika Hirvensalo, Quantum Computing, Springer.
5. Dirk Bouwmeester, Artur K. Ekert, Anton Zeilinger, The Physics of Quantum Information: Quantum Cryptography, Quantum Teleportation, Quantum Computation, Springer.
6. J. J. Sakurai, Modern Quantum Mechanics, Addison Wesley.

CSM303H	Introduction to Cryptography	Credits: 4

Divisibility, Euclidean Algorithm, Congruence's, Finite Fields, Quadratic Residues and Reciprocity, One-way and Trapdoor Functions, Stream Ciphers, Pseudo-Random Number Generators, Block Ciphers and Modes of Operations, Data Encryption Standard, Private Key Encryption, Public Key Encryption, RSA Cryptosystem, Rabin's Public Key Cryptosystem, Knapsacks, Message Authentication and Hash Functions, Digital Signatures, RSA Digital Signature Scheme, El Gamal's Scheme, Rabin's Scheme, Key Distribution, Diffie-Hellman Secret Key Exchange, Two-Party and Multi-Party Protocols, Simultaneous Secret Exchange Protocol, Secret Sharing.

Suggested Readings:

1. Bruce Schneier, Applied Cryptography: Protocols, Algorithms, and Source Code in C, Second E/d, John Wiley & Sons, 1996.
2. William Stallings, Cryptography and Network Security: Principles and Practice, Second Edition, Prentice Hall, 1998.
3. Neal Koblitz, A Course in Number Theory and Cryptography, Springer-Verlag.
4. A. J. Menezes, P. C. van Oorshot and S. A. Vanstone: Handbook of Applied Cryptography, CRC Press.

5. Shafi Goldwasser, Mihir Bellare, Lecture Notes on Cryptography. www.cse.ucsd.edu/~mihir/papers/gb.html
6. O. Goldreich, Foundations of Cryptography: Basic Tools, Cambridge University Press.

CSM303I	Advanced course in Software Engineering	Credits: 4

Software Metrics: Surveys, Experiment, Case studies, Internal and external software metrics, Reliability and quality metrics, Software management metrics.
Unified Modeling Language: Structure Diagrams: Class Diagram, Object Diagram, Component Diagram, Composite Structure Diagram, Package Diagram, and Deployment Diagram. Behavior Diagrams: Use Case Diagram (used by some methodologies during requirements gathering); Activity Diagram, and State Machine Diagram. Interaction Diagrams**:**Sequence Diagram, Communication Diagram, Timing Diagram, and Interaction Overview Diagram.
Software Reuse: Design patterns, Frameworks: development methodology, instantiation, CBSE.

Extreme Software Engineering approaches: Problems of traditional approaches, An agile process, Models of agile processes, Pair programming, Planning in an agile process, Testing in an agile process.

Software architecture: Architecture styles, Architecture Description Languages, Architecture frameworks

Suggested Readings:
1. Software Metrics- A Rigorous & Practical Approach, Fenton & Pleeger, International Thomson Computer Press.
2. Software Architecture- Perspectives on an Emerging Discipline, Shaw & Garlan, Prentice-Hall.
3. Design Patterns- Elements of Reusable Object-Oriented Software, Gamma, Helm, Johnson & Vlissides, Addison Wesley.
4. Extreme Programming And Agile Processes In Software Engineering, Jutta Eckstein, Hubert Baumeister, Springer, 2004.
5. UML- in a nutshell- A Desktop Quick Reference, Albir, O'Reilly.

CSM304M	Bioinformatics Algorithms(only for computer science and computer application students)	Credits: 3

Biological Algorithms versus Computer Algorithms, Algorithmic Notations, Algorithm Design Techniques: Exhaustive Search, Greedy Algorithm, Dynamic Programming, Branch-and-Bound Algorithms, Randomized Algorithms, Machine Learning, Tractable versus Intractable Problems, Introductory Molecular Biology, DNA Analysis, Regulatory Motifs in DNA Sequences, Finding Motifs, Greedy Approach to Motif finding, Longest Common Subsequences, Global and Local Sequence Alignments, Multiple Alignment, Gene Prediction, Constructing Algorithms in sub quadratic time, Shortest Superstring Problem, Sequencing by Hybridization, Protein Sequencing and Hybridization, Spectrum Graphs, Spectral Convolution, Repeat Finding, Hash Tables, Keyword Trees, Suffix Trees and its Applications, Approximate Pattern Matching, Hierarchical Clustering, Evolutionary Trees, Parsimony Problem, Hidden Markov Models, Applications of HMM.

Suggested Readings:
1. N. C. Jones, P. A. Pevzner, An Introduction to Bioinformatics Algorithms, MPI Press 2004.
2. D. W. Mont, Bioinformatics: Sequence and Genome Analysis, CSHL Press.
3. D. Gusfield, Algorithms on Strings, Trees, and Sequences: Computer Science and Computational Biology, Cambridge University Press, 1997.

CSM305M	Simulation and Modeling(only for computer science and computer application students)	Credits: 3

Simulation and its uses, Definition of System, Types of Systems, Simulation Experiments and Field Experiments, Random Number Generators from Uniform and other Continuous and Discrete Distributions, Tests of Randomness and Goodness of Fit.
Modeling Process and Concepts of Mathematical Models, Differential, Partial Differential and Difference Equation Models, Modeling through Graphs, Stochastic Models, Monte-Carlo Integration, Simulation of Single Server System, Inventory System, Time Sharing Computer System, and Ethernet Model. Verification, Validation and Comparison of Real System and Simulation Experiments Data, Variance Reduction Techniques, Simulation Languages: SIMULA, SIMSCRIPT and GPSS.
Suggested Readings:

1. J. A. Payne, Introduction to Simulation, Programming Techniques and Methods of Analysis, Tata McGraw Hill Publishing Co. Ltd.
2. A. M. Law, W. D. Kelton, Simulation Modeling and Analysis, McGraw Hill.
3. M. H. MacDougall, Simulating Computer Systems: Techniques and Tools, The MIT Press Cambridge.
4. Z. A. Klarian, EJ Dudewicz, Modern Statistical Systems and GPSS Simulation, Computer Science Press.
5. G. Gordon, System Simulation, PHI.
6. Narsingh Deo, System Simulation with Digital Computer, PHI.
7. JN Kapoor, Mathematical Modeling, Wiley Eastern Ltd.
8. BP Zeigler, H Praehofer, TG Kim, Theory of Modeling and Simulation-Integrating Discrete Event and Continuous Complex Dynamic Systems, Academic Press 2000.

CSM306M	**Operation Research(only for computer science and computer application students)**	**Credits: 3**

Network Analysis: Terminology of network, shortest route problem, minimal spanning tree problem, max-flow problem.
Project Scheduling by PERT, CPM: Diagram, representation, critical path calculation, construction of time chart and resource labeling, probability and cost consideration in project scheduling, project control.
Linear Programming: Simplex Method, Revised simplex method, Duality in Linear programming, Application of Linear Programming to Economic and Industrial Problems.
Nonlinear Programming: The Kuhn-Tucker conditions, Quadratic programming, Convex programming.
Replacement Models: Introduction, Replacement policies for items whose efficiency deteriorates with time, Replacement policies for items that fail completely.
Sequencing Model: Classification of self problems, processing of n jobs through two machines, three machines, processing of two jobs through m machines.

Suggested Readings:

1. Taha, Operations Research, Macmillan.
2. B.E. Gillet, Introduction to Operations Research, McGraw-Hill.
3. S.S.Rao, Optimization Theory and Applications, Wiley Eastern.
4. G.Hadley, Linear programming, Addison-Wesley.

CSM307	***Lab. Exercises based on course CSM301***	**Credits: 3**

This paper consists of programming exercises based on course CSM301: Parallel Computing.

CSM308	***Lab. Exercises based on course CSM302***	**Credits: 3**

This paper consists of programming exercises based on course CSM302: Internals of UNIX OS and Network Programming.

SEMESTER IV

CSM401	**Dissertation**	**Credits: 18**

Students will be required to pursue a dissertation allotted to them in accordance with their preference subject to their supervisor's approval. They will have to submit the dissertation done by them during the semester.

CSM402	**Comprehensive Viva**	**Credits: 7**

A Comprehensive Viva to judge students' overall academic attainments during the program.

MCA: MASTER OF COMPUTER APPLICATIONS (Six Semester Course)
Department of Computer Science
Banaras Hindu University

Semester-wise Distribution of Courses and Credits

MCA SEMESTER I		
Course No.	***Course Title***	***Credits***
CAM101	Introduction to Computer Programming through C	4
CAM102	Discrete Mathematical Structures	4
CAM103	Operating System Concepts	4
CAM104M	*Minor Elective*: Business Accounting (only for computer science and computer application students)	3
CAM105	*Lab. Exercises based on course CAM101*	3
CAM106	*PC Software Laboratory*	3
	Total	**21**
MCA SEMESTER II		
CAM201	Computer Organization and Architecture	4
CAM202	Database Management Systems	4
CAM203	Data and File Structures	4
CAM204M CAM205M	*Minor Elective*: Any one of the following courses(only for computer science and computer application students) E-commerce Numerical Computing	3
CAM206	*Lab. Exercises based on courses CAM201 (Credit : 1) and CAM202(Credit:2)*	3
CAM207	*Lab. Exercises based on course CAM203*	3
	Total	**21**
MCA SEMESTER III		
CAM301	Design Methods and Analysis of Algorithms	4
CAM302	Object Oriented Programming through JAVA	4
CAM303	Data Communication and Computer Networks	4
CAM304M	*Minor Elective*: Theory of Computation (only for computer science and computer application students)	3
CAM305	*Lab. Exercises based on course CAM301*	3
CAM306	*Lab. Exercises based on course CAM302*	3
	Total	**21**
MCA SEMESTER IV		
CAM401	Compiler Design	4
CAM402	Computer Graphics	4
CAM403	Artificial Intelligence	4
CAM404	Software Engineering	4
CAM405	Technical Writing and Research Seminar	4
CAM406	*Lab. Exercises based on course CAM401*	3
CAM407	*Lab. Exercises based on course CAM402*	3
	Total	**26**
MCA SEMESTER V		
Course No.	***Course Title***	***Credits***
CAM501	Parallel Computing	4
CAM502	Internals of UNIX OS and Network Programming	4
CAM503(A-F)	Elective Course I: Any one of the following CAM503A: Advanced Computer Architecture CAM503B: Soft Computing Techniques CAM503C: Information Retrieval and Web Mining CAM503D: Distributed Systems CAM503E: Science of Programming CAM503F: Advanced DBMS	4
CAM504(A-F)	Elective Course II: Any one of the following CAM504A: Bioinformatics Algorithms CAM504B: Simulation and Modeling	3

	CAM504C: Operation Research CAM504D: Quantum Computing CAM504E: Introduction to Cryptography CAM504F: Advanced course in Software Engineering	
CAM505	*Lab. Exercises based on course CAM501*	3
CAM506	*Lab. Exercises based on course CAM502*	3
	Total	**21**
MCA SEMESTER VI		
CAM601	Dissertation	18
CAM602	Comprehensive Viva	7
	Total	**25**
	Grand Total	**135**

SEMESTER I

CAM101	Introduction to Computer Programming through C	Credits: 4

Basic Programming Concepts: Introduction to the basic ideas of problem solving and programming using principles of top-down modular design, Flowcharts, Abstraction Mechanisms, Stepwise Refinement.
Syntactic Elements of a Language, General Syntactic Criterion, Formal Definition of Syntax, Semantics, Storage Management, Static Storage Management, Stack-Based Storage Management, Heap Storage Management, Operating and Programming Environment.
Introduction to Programming Language C: Data Types, Instruction and its Types, Storage Classes, Operators and Hierarchy of Operations, Expressions in C, Control and Repetitive Statements, break, continue, Functions: User Defined Functions and Library Functions, Local and Global Variables, Parameter Passing, Pointers, Arrays, Strings, C Preprocessors, Structures, Input and Output in C, C-Library.
Introduction to the Major Programming Paradigms: Imperative Language, Object Oriented Languages, Functional Languages, Logic Languages, Parallel Languages etc.

Suggested Readings:

1. R. Sethi, Programming Languages: concepts and constructs, Addison-Wesley, 1996.
2. T.W. Pratt, Programming Languages, McGraw Hills.
3. C. Ghezzi & M. Jazayeri, Programming Languages Concepts, John Wiley.
4. M. Marcotty & H.F. Ledgard, Programming Language Landscape, Galgotia Publication.
5. B.W. Kernighan and D.M.Ritchie, the C Programming Language, PHI.
6. R.C. Hutchinson and S.B. Just, Programming using the C Language, McGraw-Hill.
7. B.S. Gottfried, Schaum's Outline of Theory and Problems of Programming with C, McGraw-Hill.
8. H. Schildt, C Made Easy, Osborne McGraw-Hill.
9. Y. Kanetkar, Let Us C, BPB Publications.

CAM102	Discrete Mathematical Structures	Credits: 4

Sets, Relations & Functions: Property of binary relations, equivalence, compatibility, partial ordering relations, hasse diagram, functions, inverse functions, composition of functions, recursive functions.
Mathematical Logic: Logic operators, Truth tables, Theory of inference and deduction, mathematical calculus, predicate calculus, predicates and quantifiers.
Groups & Subgroups: Group axioms, Monoids , semi groups, Isomorphism, homomorphism , automorphism.
Lattices & Boolean Algebra: Truth values and truth tables, the algebra of propositional functions, Boolean algebra of truth values.
Combinatorics & Recurrence Relations: Permutation, Combination, Principle of Inclusion and Exclusion, Recurrence Relations, Generating Functions
Graph theory: Basic Concepts of Graphs and Trees, Adjacency and Incidence Matrices, Spanning Tree, Transitive Closure, Shortest Path, Planar Graphs, Graph Coloring, Eularian and Hamiltonian graphs, Applications of Graph Theoretic Concepts to Computer Science.

Suggested Readings:

1. J.P. Trembley and R.P.Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill.
2. Dornhoff and Hohn, Applied Modern Algebra, McMillan.
3. N. Deo, Graph Theory with Applications to Engineering and Computer Science, PHI.
4. R. Johnsonbaugh, Discrete Mathematics, Pearson Education, 2001.
5. R. P. Grimaldi, Discrete and Combinatorial Mathematics, Pearson Education, 1999.
6. C.L. Liu, Elements of Discrete Mathematics, McGraw-Hill.
7. Rosen, Discrete Mathematics, Tata McGraw Hill.

CAM103	Operating System Concepts	Credits: 4

Introduction: Definition, Design Goals, Evolution; Concept of User, job and Resources; Batch processing, Multi-programming, Time sharing; Structure and Functions of Operating System.
Process Management: Process states, State Transitions, Process Control Structure, Context Switching, Process Scheduling, Threads.
Memory Management: Address Binding, Dynamic Loading and Linking Concepts, Logical and Physical Addresses, Contiguous Allocation, Fragmentation, Paging, Segmentation, Combined Systems, Virtual Memory,

Demand Paging, Page fault, Page replacement algorithms, Global Vs Local Allocation, Thrashing, Working Set Model, Paging.
Concurrent Processes: Process Interaction, Shared Data and Critical Section, Mutual Exclusion, Busy form of waiting, Lock and unlock primitives, Synchronization, Classical Problems of Synchronization, Semaphores, Monitors, Conditional Critical Regions, System Deadlock, Wait for Graph, Deadlock Handling Techniques: Prevention, Avoidance, Detection and Recovery.
File and Secondary Storage Management: File Attributes, File Types, File Access Methods, Directory Structure, File System Organization and Mounting, Allocation Methods, Free Space management; Disk Structure, Logical and Physical View, Disk Head Scheduling, Formatting, Swap Management. Protection & Security.
UNIX/ LINUX and WINDOWS as example systems.

Suggested Readings:

1. Silberschatz and Galvin, Operating System Concepts 6/ed, Addison Wesley.
2. William Stalling, Operating Systems: Internals and Design Principles 5/ed, PHI.
3. Tanenbaum, Modern operating Systems, PHI.
4. J Bach, The Design of UNIX Operating System, Pearson Education.
5. Vijay Mukhi, The C Odessy, BPB.
6. Peterson and Silberschatz, Operating System Concepts, Addison Wesley.
7. P. B. Hansen, Operating System Principles, PHI.
8. K. Christian, The UNIX Operating System, John Wiley.
9. A. N. Haberman, Introduction to Operating System Design, Galgotia.
10. Manuals of DOS, UNIX and Netware.

CAM104M	***Minor Elective*: Business Accounting (only for computer science and computer application students)**	**Credits: 3**

Introduction, Definition, Concepts and Conventions of Accounting, Principles of Double Entry System, Recording, Classification and Summarization of business transactions, Preparation of Cash Book and Bank Reconciliation statement.
Final Accounts: Final Accounts of Sale proprietary concern, Partnership and Joint Stock Companies.
Cost Accounting: Definition, objectives and significance of cost Accounting, cost Accounting vs. Financial Accounting, Classificvation of costs, Preparation of Cost sheet.

Suggested Readings:

1. J. Kellock, Elements of Accounting, Heinemann.
2. R.L .Gupta & M. Radhaswamy, Advanced Accountancy, Sultan Chand.
3. Dr. S.M. Shukla, Advanced Accounting, Sahitya Bhawan.
4. Jawahar Lal, Cost Accounting, Tata McGraw Hill.
5. S.P. Jain and K.L. Narang, Cost Accounting, Kalyani Publishers.

CAM105	***Lab. Exercises based on course CAM101***	**Credits: 3**

This paper consists of programming exercises based on course CAM101, Introduction to Computer Programming through C.

CAM106	***PC Software Laboratory***	**Credits: 3**

MS-Office Package: MS Word, MS-Excel, MS-Powerpoint, MS Access and Latex.

Suggested Readings:

1. Jennifer Ackerman Kettell, Guy Hart-Davis, Curt Simmons, Microsoft Office 2003 : the complete reference, McGraw-Hill/Osborne, 2003.
2. Laurie Ann Ulrich, NetLibrary, Inc., Sams teach yourself Microsoft Office 2000 in 21 days, Sams publishing, 1999.
3. Gini Courter; Annette Marquis, Mastering Office XP for business professionals, SYBEX, 2003.

MCA- SEMESTER II

CAM201	Computer Organization and Architecture	Credits: 4

Basic Organization : Von Neumann Machine (IAS Computer), Operational flow chart (Fetch, Execute), Instruction Cycle, Organization of Central Processing Unit, Hardwired & micro programmed control unit, Single Organization, General Register Organization, Stack Organization, Addressing modes.
Memory Organization : Memory Hierarchy, Main memory (RAM/ROM chips), Auxiliary memory, Associative memory, Cache memory, Virtual Memory, Memory Management Hardware, hit/miss ratio, magnetic disk and its performance, magnetic Tape etc.
I/O Organization : Peripheral devices, I/O interface, Modes of Transfer, Priority Interrupt, Direct Memory Access, Input-Output Processor, and Serial Communication. I/O Controllers, Asynchronous data transfer, Strobe Control, Handshaking.
Instruction Formats, Op Codes Mnemonics, Data Transfer, Arithmetic, Branch, Loop, Logical, Shift and Rotate Instructions, String Instructions and Text Processing.
Stacks, Calls, Returns, Near and Far Procedures, Interrupts and Their Routines, Directives, Pseudo-ops, Macros and Conditional Machine Instructions, Disk File Handling, Input and Output Instructions, Device Drivers.

Suggested Readings:

1. Y.C. Liu and G.A. Gibson : Microcomputer System – 8086/8088 Family (P.Hall).
2. P. Abel : IBM PC Assembly Language Programming (PHI).
3. M. Thorn : Programming the 8086/8088 (Benjamin).
4. J.P. Hayes, Computer Architecture and Organization, 3rd ed., McGraw Hill.
5. M. M. Mano, Computer System Architecture, PHI.
6. M. M. Mano, Digital Logic and Computer Design (PHI).
7. V. Rajaraman, T. Radhakrishnan, An Introduction to Digital Computer Design, PHI, 2006.
8. William Stallings, Computer Organization And Architecture: Designing For Performance, Prentice Hall, 2005.

CAM202	Database Management Systems	Credits: 4

Database Systems, View of Data Models, Database Languages, DBMS Architecture, Database Users and Data Independence.
ER Modeling, relation types, role and Structural Constraints, Extended ER Modeling Features, Design of an ER Database Schema, Reduction of ER Schema to Tables. Relational Model: Relational Model Concepts, Relational Algebra, Relational Calculus.

Introduction to SQL: SQL data types and literals, Types of SQL commands, SQL operators, Tables, views and indexes, Queries and sub queries, Aggregate functions, Cursors in SQL.
Relational Database Design: Functional and multi-valued Dependencies, Desirable Properties of Decomposition, Normalization up to 5 NF.
Concept and Design of Object Oriented Database.
Selected Database Issues: Security, Transaction Management, Basic Algorithms to Query Processing and Query Optimization, Concurrency Control, Recovery Techniques.
Case Study: Oracle/MS-SQL.

Suggested Readings:

1. C.J.Date, An Introduction to Database Systems, Vol I & II, Addison Wesley.
2. Korth Silberschatz, Data Base System Concepts, 4th ed., McGraw Hill.
3. J.D.Ullman, Principles of Database Systems, Golgotha, New Delhi.
4. Wiederhold, Database Design, McGraw Hill.
5. R. Elmasri, and S.B. Navathe, Fundamentals of Database Systems, Pearson Education Asia.
6. Raghu Ramakrishnan, Database Management Systems, McGraw-Hill Education.

CAM203	Data and File Structures	Credits: 4

Basic Data Structures : Arrays, Linked Lists, Stack, Queue, Dequeue, Tree, Heap, Hashing, Hash Table and Collision resolution, Representation of Graphs and Applications. Basic algorithms for Creation, Manipulation and Applications of Data Structures. Algorithm Complexity and Time-Space trade-off.
Internal Sorting Algorithms : Selection, Bubble, Insertion, Heap, Quick Sort. External Sorting Algorithms: Merge Sort.

File Structures: Primary File Organization: Sequential, Direct, Indexed Sequential, Multi-list File Organization, Inverted Files.

Suggested Readings:

1. Lipshutz, Data Structure, McGraw Hill.
2. Standish, Data Structure, Addison-Wesley.
3. B. Salzberg, File Structures - An Analytic Approach, Prentice-Hall.
4. A.L. Tharp, File Organization and Processing, John Wiley and Sons.
5. A. M. Tennenbaum, Y. Langsam and M. J. Augenstein, Data Structures using C, PHI, 1996.
6. S. Lipschutz, Data Structure, Schaum Series.
7. D. E. Knuth, Fundamental Algorithms, Narosa Publication.
8. N. Wirth, Algorithms+Data Structures= Program, Prentice Hall.
9. Robert Lafore, Data Structures and Algorithms in Java, Sams.
10. Sahni S, data Structures, Algorithms and Applications in C++ , Mc Graw- Hill, 2002.

CAM204M	***Minor Elective*: (only for computer science and computer application students)** **E-commerce**	**Credits: 3**

Introduction, Definition, Objectives, Advantages and disadvantages, Forces driving E-Commerce, Traditional commerce Vs. E-Commerce, E-Commerce opportunities for industries, Growth of E-Commerce.
E-Commerce Models: Business to consumer, Business to Business, Consumer to Consumer, other models – Brokerage Model, Aggregator Model, Info-mediary Model, Community Model and value chain Model.
Electronic Payment Systems: Special features required in payment systems, Types of E-payment systems, E-Cash, E-cheque, credit card, Smart Card, Electronic Purses.
E-Marketing, E-Customer Relationship Management, E-Supply Chain Management.
Security Issues in E-Commerce: Security risk of E-Commerce, Types of threats, Security tools and risk management approach. Cyber laws, Business Ethics, IT Acts.

Suggested Readings:

1. Bharat Bhaskar, Electronic Commerce – Frameroork Technologies and Applications, Tata McGraw Hill.
2. Ravi Kalakota & A.B. Whinston, Frontiers of Electronic Commerce, Pearson Education.
3. Ravi Kalakota & A.B. Whinston, Electronic Commerce – A Manager's Guide, Pearson Education.
4. Agarwala Kamlesh, N and Agarwala Deeksha, Business on the Net_Introduction to the E-Com., Macmillan India.
5. P. T. Joseph, E-Commerce: A Managerial Perspective, PHI, 2002.

CAM205M	***Minor Elective*:: Numerical Computing (only for computer science and computer application students**	**Credits: 3**

Note : Emphasis is on computational methods

Errors in Computer Arithmetic, Normalization.
Bisection, Falsiposition and Newton-Raphson methods for solution of nonlinear equations. Errors in the solutions, Convergence of Solutions.
Gauss, Gauss-Siedel and Iterative methods for system of linear equations. Ill conditioned system, Pivotal Condensation, Matrix Inversion, Eigen-values, Eigen-vector, Diagonalization of Real Symmetric Matrix by Jacobi's Method.
Introduction to Finite Differences.
Polynomial Interpolation using Newton's and Lagrange's formulae.
Numerical Differentiation. Numerical Integration : Trapezoidal Rule, Simpson's Rule, Weddle's Rule, Gauss Quadrature Formula. Error in numerical Integration.
Numerical Solution of differential Equations: Picards Method, Taylor's Series Method, Euler's Method, Modified Euler's Method, Runge-Kutta Method, Predictor-Corrector Method.

Suggested Readings:

1. V. Rajaraman, Computer Oriented Numerical Methods, PHI.
2. F.Acton, Numerical Methods that Work, Harper and Row.
3. S. D. Conte and C.D.Boor, Elementary Numerical Analysis, McGraw Hill.

4. S. S. Shastri, "Introductory Methods of Numerical Analysis", PHI.
5. C. F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Addision Wesley.

CAM206	*Lab. Exercises based on courses CAM201 and CAM202*	Credits: 3

This paper consists of lab exercises based on course: CAM201 (Credit: 1): Computer Organization and Architecture and CAM202 (Credit: 2), Database Management Systems.

CAM207	*Lab. Exercises based on course CAM203*	Credits: 3

This paper consists of programming exercises based on paper: CAM203, Data and File Structures.

MCA- SEMESTER III

CAM301	Design Methods and Analysis of Algorithms	Credits: 4

Elementary Data Structures, Basic Computational Models.
Simple Algorithms. Analyzing Algorithms, Asymptotic Notation, Recurrence relations.
Design Methods : General Consideration, Algorithm design paradigms and representative problems: Divide and Conquer (Binary search, Merge Sort, Quick Sort, Arithmetic with Large integers, etc.), Greedy Method (Minimal Spanning Tree, Shortest Paths, Knapsack, etc.), Dynamic Programming (Chained Matrix Multiplication, Optimal Storage on Tapes, Shortest Paths, Optimal Search Trees, etc.), Backtracking (8-queens problem, Graph Colouring, Hamiltonian Cycles, etc.), Branch and Bound (0/1 Knapsack problem, Travelling Salesperson, etc.), Approximation (Graph Colouring, Task Scheduling, Bin Packing, etc.), Probabilistic Algorithms (Numerical Integration, Primality Testing, etc.).
Graph Algorithms: BFS, DFS and its applications.
Polynomial Evaluation and Interpolation, Fast Fourier transforms.
Intractable Problems : Basic Concepts, Nondeterministic Algorithms, NP Completeness, Cook's Theorem, Examples of NP-Hard and NP-Complete problems. Problem Reduction.
Lower Bound Techniques: Comparison tree, Reduction, Adversary argument.

Suggested Readings:

1. A.Aho, V. Alfred, J. Hopcroft and J. D. Ullman, The Design and Analysis of Computer Algorithms, Addison Wesley.
2. E. Horowitz and S. Sahani, Fundamentals of Computer Algorithms, Galgotia, New Delhi.
3. S.E. Goodman and S.T. Hedetniemi, Introduction to the Design and Analysis of Algorithms, McGraw Hill.
4. G. Brassard and P. Bratley, Algorithmics, PHI.
5. S. K. Basu, Design Methods and Analysis of Algorithms, PHI, 2005.
6. Anany V. Levitin, Introduction to the Design & Analysis of Algorithms, Addison Wesley.

CAM302	Object Oriented Programming through JAVA	Credits: 4

Object Oriented Analysis and Design Concepts: Object Modeling Technique; General Concepts: Object, Class, Data Abstraction and Encapsulation, Inheritance, Polymorphism, Dynamic Binding, Message Passing; Benefits of OOP, Object-oriented Languages.
Object oriented Programming using JAVA:
Language Basics- Variables Primitive Data Types Operators Expressions, Statements, and Blocks Control Flow Statements Arrays, Classes and Objects, Constructors and Destructors, Operator Overloading, Type Conversions, Inheritance, Interfaces, Packages, Threads, Exception handling, colors, fonts and graphics, Applets, working with input/output.

Suggested Readings:

1. Rodgers Cadenhead, Laura Lemay, Sams Teach Yourself Java 2 in 21 Days, Sams Publishing.
2. E. Balagurusamy, Programming with Java, Tata McGraw Hill.
3. Bruce Eckel, Thinking in Java, Pearson Education.
4. Peter Van Der Linden, Just Java 2, Sun Microsystems/Prentice Hall

CAM303	Data Communication and Computer Networks	Credits: 4

Introduction, Networks models – OSI model, Internet model.
Physical layer : Signals - Analog, Digital, Digital transmission - Coding, Sampling, Analog Transmission - Modulation of Digital and analog signals, Multiplexing, Switching, Transmission Media.
Data link layer : Error detection and Correction, Data link control and protocol, Point to point access, Multiple access , LANS- Traditional Ethernet, Fast Ethernet, Gigabit Ethernet, Wireless LAN's - IEEE 802.11, Blue tooth, Connecting LANs - Connecting devices, Satellite networks.
Network layer : Internetworking, Addressing, Routing, Networks layer protocols – ARP , IP, ICMP, Ipv6, Routing- Introduction, Routing Algorithms & Protocols.
Transport layer : UDP, TCP, Congestion and Control, Quality of service (QOS) and techniques to improve QOS.
Application layer : DNS, Electronic mail, SMTP, File transfer, FTP, HTTP, World wide web, Network Security, Network Management Protocol.

Suggested Readings:

1. W.Stallings, Data and Computer Communication, McMillan.
2. A.S.Tanenbaum, Computer Networks, PHI.
3. J. Martin, Computer Network and Distributed Data Processing, Prentice Hall.
4. W.Stallings, Local Networks, McMillan.
5. M.Schwertz, Computer Communication Network Design and Analysis, Prentice Hall.
6. B. A. Forouzan, Data Communications and Networking, TMH, 2003.
7. Keshav, An Engineering Approach to Computer Networks, Addison-Wisley.
8. Peterson and Davie, Computer Networks, Morgan and Kaufmann, 2000.

CAM304M	*Minor Elective*: Theory of Computation (only for computer science and computer application students)	Credits: 3

A brief review of Finite Automata, Regular expressions, Regular languages, Deterministic and non-deterministic computations. Pumping Lemma for Regular languages, Context free languages, Pushdown automaton, Pumping Lemma for Context free languages, Grammar types and Chomsky Hierarchy. Turing Machines (TM), Variations of TM's, Universal Turing Machines (UTM), Church-Turing Thesis, Relation of Languages to Automata. Turing computable functions, Halting problem, Solvability, Undecidability and Computability.

Suggested Readings:

1. J.E.Hopcraft, R. Motwani and J.D. Ullman, "Introduction to Automata Theory, Languages and Computation", Pearson Education
2. Cohen, "Introduction to Computer Theory", John Wiley.
3. M. Sipser, Introduction to Theory of Computation, PWS Publishing Corporation, 1997.
4. J.E. Hopcroft, J.D. Ullman, Introduction to Automata Theory, Languages and Computation, Addison-Wisley.
5. T.C. Martin, Theory of Computation, Tata McGraw-Hill
6. H.R. Lewis, C.H. Papadimitrou, Elements of the Theory of Computation, PHI.

CAM305	*Lab. Exercises based on course CAM301*	Credits: 3

This paper consists of programming exercises based on course CAM301: Design Methods and Analysis of Algorithms.

CAM306	*Lab. Exercises based on course CAM302*	Credits: 3

This paper consists of programming exercises based on course CAM302: Object Oriented Programming through JAVA.

MCA- SEMESTER IV

CAM401	Compiler Design	Credits: 4

Compilers and Translators, Syntactic and lexical structure of a language.
Finite Automata and design of lexical analyzer, Context free grammars and derivation of parse trees, basic parsing techniques: shift-reduce, operator-precedence, top-down, predictive. Disambiguation of grammar.
Automatic construction of efficient parsers: LR parser, construction of parsing tables. Syntax Directed Translation, L-attributed and S-attributed Definitions.
Code Generation and Code Improvement.
Symbol table organization, Run time storage management, Error detection and recovery.

Suggested Readings:

1. Aho, Ullman and Sethi, Principles of Compiler Design, Addison Wesley.
2. J. P. Trembley and P. G. Sorensen, The Theory and Practice of Compiler Writing, McGraw Hill.
3. Holub, Compiler Design in C, PHI.

CAM402	Computer Graphics	Credits: 4

Introduction to Computer Graphics, Display Technologies, Random and Raster Scan, frame buffer, bit plane, Input Devices, Graphics Standards, Graphics Hardware.
Line and Circle Drawing Algorithms, Scan Conversion, filling algorithms, clipping, Two and Three Dimensional transformations, Homogeneous Coordinates, Rigid Body and Affine transformations, Parallel and perspective projections, vanishing points, viewing transformation, Hidden line removal method, Curve and Surface: Cubic Spline, Bezier curve, B-Spline Curves, Parametric Surface, Surface of revolution, Sweep surface, Fractal Curves and surfaces.

Suggested Readings:

1. Computer Graphics (Principles and Practice) by Foley, van Dam, Feiner and Hughes, Addisen Wesley (Indian Edition)
2. Computer Graphics by D Hearn and P M Baker, Printice Hall of India (Indian Edition).
3. Mathematical Elements for Computer Graphics by D F Rogers.

CAM403	Artificial Intelligence	Credits: 4

Introduction: Definitions and approaches, Foundations of A.I., History of AI, Areas and state of the art in A.I., A.I. Programming languages, Concept of Intelligent Agents.

Problem Solving: Problem solving as state space search, production system, control strategies and problem characteristics; Search techniques: Breadth First and Depth-first, Hill-climbing, Heuristics, Best-First Search, A* algorithm, Problem reduction and AO* algorithm, Constraints satisfaction, Means Ends Analysis, Game Playing.

Knowledge Representation and Reasoning: Syntactic and Semantic representations, Predicate and prepositional logic, Resolution, Unification, Deduction and theorem proving, Question answering; Forward versus backward reasoning, Matching, Indexing;
Ontological Engineering, Formal Theory of Beliefs, Semantic Net, Frames, Conceptual Dependencies and Scripts, Truth Maintenance Systems.

Selected Topics and Applications: Philosophical issues, Introduction to Natural Language Processing, Expert Systems and Multiagent Systems.

Suggested Readings:

1. S. Russel, P. Norvig, Artificial Intelligence: A Modern Approach, Pearson Education.
2. E. Rich and K. Knight, Artificial Intelligence, Tata McGraw Hill.
3. N.J. Nilsson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann.

CAM404	Software Engineering	Credits: 4

Introduction to Software Engineering: Definition; Software development and life-cycle models, CMM, Software Quality, role of metrics and measurement.

Requirements Analysis and Specification: SRS Building Process, Specification Languages, Validation of SRS, metrics, monitoring and control, Object Oriented analysis.

Software Project Planning: Software Cost Estimation Techniques, Project Scheduling & Tracking, Project Team Standards, software configuration management, management.

Software Design and Implementation: Design Concepts and Notations, Functional & Object Oriented Design Concepts, Design Strategies, Design specification and verification, Metrics, Design Translation Process.

Testing Strategies & Techniques, Debugging, Software Maintenance,

Metrics and Models: Design Metrics, Complexity Metrics, Software Reliability and Availability Models, etc. Software Reengineering, Cleanroom Approach, Software Reuse.

Introduction to IEEE Standards, Case Studies.

Suggested Readings:

1. "An Integrated Approach to Software Engineering", Pankaj Jalote, IIIrd Edition, Narosa Publishing House.
2. "Software Engineering: Principles and Practices", Waman S. Jawadekar, Tata McGraw-Hill.
3. "Software Engineering: A Practitioner's approach", Roger S. Pressman, McGraw-Hill.
4. "Software Engineering:, Ian Sommerville, Pearson Education.
5. "Fundamentals of Software Engineering", Carlo Ghezzi, Mehdi Jazayeri, Dino Mandrioli, PHI.
6. S. L. Pfleeger, Software Engineering: Theory and Practice, Pearson Education.

CAM405	Technical Writing and Research Seminar	Credits: 4

Students will be required to write a Paper on a topic approved by the department and to give a presentation based on it.

CAM406	*Lab. Exercises based on course CAM401*	Credits: 3

This paper consists of programming exercises based on course CAM401: Compiler Design.

CAM407	*Lab. Exercises based on course CAM402*	Credits: 3

This paper consists of programming exercises based on course CAM402: Computer Graphics.

MCA- SEMESTER V

CAM501	Parallel Computing	Credits: 4

Introduction to Parallel Computing: Supercomputers and grand challenge problems, Modern Parallel Computers, Data Dependence Graph, Data Parallelism, Functional Parallelism, Pipelining and Data Clustering.
Interconnection Networks: Switch Network Topologies, Direct and Indirect Network Topology, Bus, Star, Ring, Mesh, Tree, Binary Tree Network, Hyper Tree Network, Hybrid, Hypercube, Perfect Shuffle Network, Torus and Butterfly Network.
Performance Analysis: Introduction, Execution Time, Speedup, Linear and Superlinear Speedup, Efficacy and Efficiency, Amdahl's Law and Amdahl Effect, Gustafson-Barsis's Law, Minsky's Conjecture, The Karp-Flatt Metric, The Isoefficiency Metric, Isoefficiency Relation, Cost and Scalability.
Parallel Computational Models: Flynn's Taxonomy, PRAM, EREW, CREW, ERCW, CRCW, Simulating CRCW, CREW & EREW, PRAM algorithms.
Introduction to Parallel Algorithms: Parallel Programming Models, PVM, MPI Paradigms, Parallel Programming Language, Brent's Theorem, Simple parallel programs in MPI environments, Parallel algorithms on network, Addition of Matrices, Multiplication of Matrices.

Suggested Readings:

1. Hwang and Briggs, Computer Architecture and Parallel Processing, McGraw Hill.
2. Crichlow, Introduction to Distributed and Parallel Computing, PHI.
3. M.J.Quinn, Designing Efficient Algorithms for Parallel Computers, McGraw-Hill.
4. V.Rajaraman, Elements of Parallel Computing, Prentice-Hall of India.
5. Joseph JA JA, Introduction to Parallel Algorithms, Addison Wesley.
6. S.G.Akl, The Design and Analysis of Parallel Algorithms, PHI.
7. Shashi Kumar M et al. Introduction to Parallel Processing, PHI New Delhi.

CAM502	Internals of UNIX OS and Network Programming	Credits: 4

The general overview, Unix Kernel, Internal representation of files, Buffering, System calls, Process structure and control, Process scheduling, memory management, I/O subsystem, Shell Programming , IPC, Distributed UNIX systems.

The UNIX model, Inter-process communication,, Communication protocols, Berkeley sockets, Transport layer interface, Library and other routines, Security issues, FTP, Line printer spoolers, Remote login, remote execution, Remote procedure calls, Remote drive access.

Suggested Readings:

1. R. Thomas and J. Yates, A User Guide to The UNIX System, Osborne McGraw-Hill.
2. M. J. Bach, The Design of Unix Operating System, PHI, 1996.
3. B. W. Kernighan and R. Pike, The UNIX Programming Environment, PHI, 1996.
4. W.R. Stevens, UNIX Network Programming, PHI, 1997.
5. Barry Nance, Network Programming in C, PHI, 1990.

CAM503A	Advanced Computer Architecture	Credits: 4

Architectural Abstraction, Classification schemes, Parallelism: Pipelining, Multiprocessing. Issues in Branch performance, Synchronization in Multiprocessing, High Performance Processor Design Issues: Pipeline design, Memory system design, I/O design.
Instruction level parallelism, Thread and process level parallelism, Data parallelism.
Vector machines, Dependency Analysis, Vectorization, Optimization in Vector Processing, Vector Chaining , Example systems. Associative Processors and Algorithms
Super-scalar and VLIW processors, Example systems and main issues in design.
Multiprocessors: Shared Memory, Distributed Memory Architectures; Multiprocessor Interconnections,
Memory systems for Multiprocessors, Example systems; Cache Memory, coherence issues, protocols.
Multiprocessor Simulation and Measurement.

Suggested Readings:

1. D. Sima, T. Fountain, P. Kacsuk, "Advanced Computer Architectures: A Design Space Approach", Addison Wesley, 1997.
2. .J. Flynn, "Computer Architecture: Pipelined and Parallel Processor Design", Narosa Publishing House/ Jones
3. K. Hwang, "Advanced Computer Architecture: Parallelism, Scalability, Programmability", McGraw-Hill, Inc
4. Hwang and Briggs, "Computer Architecture and Parallel Processing, McGraw Hill.
5. B. Barnes, Modeling and Performance Measurement of Computer Systems, MIT Press.

CAM503B	Soft Computing Techniques	Credits: 4

Introduction to Genetic Algorithm, Genetic Operators and Parameters, Genetic Algorithms in Problem Solving, Theoretical Foundations of Genetic Algorithms, Implementation Issues.

Neural Model and Network Architectures, Perceptron Learning, Supervised Hebbian Learning, Backpropagation, Associative Learning, Competitive Networks, Hopfield Network, Computing with Neural Nets and applications of Neural Network.

Introduction to Fuzzy Sets, Operations on Fuzzy sets, Fuzzy Relations, Fuzzy Measures, Applications of Fuzzy Set Theory to different branches of Science and Engineering.

Suggested Readings:

1. M. Mitchell, An Introduction to Genetic Algorithms, Prentice-Hall.
2. D. E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley.
3. Z. Michalewicz, Genetic Algorithms+ Data Structures = Evolution Programs, Springer-Verlag.
4. N.K. Sinha & M. M. Gupta(Eds), Soft Computing & Intelligent Systems: Theory & Applications, Academic Press, 2000.
5. M.T. Hagan, H. B. Demuth, And M. Beale, Neural Network Design, Thompson Learning, 1996.
6. C. Lau (Ed), Neural Networks, IEEE Press.
7. J. Freeman and D. Skapura, Neural Networks: Algorithms, Applications, and Programming Techniques, Addison-Wesley.
8. G. J. Klir and T. A. Folger, Fuzzy Sets, Uncertainty, and Information, PHI.
9. G. J. Klir, and B. Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice-Hall, 1995.
10. H. J. Zimmerman, Fuzzy Set Theory and Its Applications, Kluwer Academic Press.

CAM503C	Information Retrieval and Web Mining	Credits: 4

Information Retrieval Concepts and Models, Introduction to World Wide Web, Hypertext Data, Search Engines, Crawling the Web.
Indexing and Search: Boolean Queries and Inverted Index, Relevance ranking, Similarity search, Web directories, Combining Searching with Browsing, Metasearchers, Web Query Languages, Dynamic Search and Software Agents.
Clustering and Classification, Social network analysis, Measuring and Modeling the Web, Question answering, Semantic Web.

Suggested Readings:

1. Baeza-Yates, R. and Ribeiro-Neto, B., Modern Information Retrieval. Pearson Education 1999.
2. Chakrabarti, S., Mining the Web, Morgan Kaufmann (An Imprint of Elsevier) 2005.
3. Grossman, D. A. and Frieder, O., Information Retrieval: Algorithms and Heuristics. Kluwer 1998.

CAM503D	Distributed Systems	Credits: 4

Distributed Systems, Communication in distributed systems, processes and processors in distributed systems. Threads, systems Models, Process allocation, scheduling in distributed systems, fault tolerance, real-time distributed systems.
Theoretical issues in distributed systems: Logical clock, mutual exclusion, deadlock detection, agreement protocols, resource security and protection, concurrency control.
Distributed File System: Design and implementation, trends.

Distributed shared Memory, consistency models, page-based distributed shared memory, shared variable distributed shared memory, object-based distributed shared memory.
Multiprocessor OS, Database OS: General features and theoretical issues.
Case Studies: Amoeba, Mach, chorus, DCE, etc.
Multimedia Operating Systems: Process scheduling, File system, caching, Disk scheduling for multimedia.

Suggested Readings:

1. A.S. Tanenbaum, Distributed Operating System, Prentice-Hall, 1995.
2. A.S. Tanenbaum, Modern Operating Systems, Pearson Education Asia, 2001.
3. M. Singhal and N. G. Shivaratri, , Advance Concepts in Operating Systems, McGraw-Hill, 1994.
4. J. W. S. Liu, Real-Time Systems, Pearson Education, 2000.

CAM503E	Science of Programming	Credits: 4

Propositions, Precedence rules for operators, Tautologies, Propositions as set of states, Equivalence Transformations, Deductive proofs, Reference Rules, Proofs and Sub-proofs
Quantification, Free and bound variables, Substitution, Assertions, Proof Outlines, Language Semantics of a Simple Language, Programming as a Goal-Oriented Activity, Loop Invariants, Developing invariants, Efficiency Considerations, Bound Function, Program Inversion.

Suggested Readings:

1. David Gries, The Science of Programming, Narosa Publishing House, New Delhi.
2. Zohar Manna, Mathematical Theory of Computation, McGraw-Hill.
3. R. G. Stone, D. J. Cooke, Program Construction, Cambridge University Press.
4. E. W. Dijkstra, A Discipline of Programming, PHI.

CAM503F	Advanced DBMS	Credits: 4

Design Theory for Relational Database: Functional Dependencies, Decomposition of Relation schemes, Normal Forms for Relations. Schemes, Multivalued and other kinds of Dependencies.
Query Optimization: Basic Optimization Strategies, Algebraic Manipulation, Optimization of Selections in System, Exact Optimization for a Subset of Relational Queries, Optimization under Weak Equivalence.
Database Protection: Integrity, Constraints in Query-by-Example, Security, Security in query-by-Example, Security in Statistical Databases.
Concurrent Operations on the Database: Basic Concepts, A simple Transaction Model, Model with Read- and Write-Locks, Read-only, Write-only Model, Concurrency for Hierarchically Structured Items, Protection against Crashes, Optimistic Concurrency Control.
Principles of Distributed Data Bases, Framework for distribution. Translation of global queries into fragment queries. Query optimization and management of distributed transaction. Concurrency control and reliability in distributed databases.
Administration of Distributed Data Bases. Example Systems.
Suggested Readings:

5. J.D.Ullman, Principles of Database Systems, Galgotia, New Delhi.
6. S.Ceri, G. Relagatti, Distributed Databases, McGraw-Hill.
7. C. Papadimitriou, The Theory of Database concurrency Control, Computer Science Press.
8. T. Ozsu, P. Valduriez, Principles of Distributed Database Systems, Prentice-Hall.

CAM504A	Bioinformatics Algorithms	Credits: 3

Biological Algorithms versus Computer Algorithms, Algorithmic Notations, Algorithm Design Techniques: Exhaustive Search, Greedy Algorithm, Dynamic Programming, Branch-and-Bound Algorithms, Randomized Algorithms, Machine Learning, Tractable versus Intractable Problems, Introductory Molecular Biology, DNA Analysis, Regulatory Motifs in DNA Sequences, Finding Motifs, Greedy Approach to Motif finding, Longest Common Subsequences, Global and Local Sequence Alignments, Multiple Alignment, Gene Prediction, Constructing Algorithms in sub quadratic time, Shortest Superstring Problem, Sequencing by Hybridization, Protein Sequencing and Hybridization, Spectrum Graphs, Spectral Convolution, Repeat Finding, Hash Tables, Keyword Trees, Suffix Trees and its Applications, Approximate Pattern Matching, Hierarchical Clustering,

Evolutionary Trees, Parsimony Problem, Hidden Markov Models, Applications of HMM.

Suggested Readings:

1. N. C. Jones, P. A. Pevzner, An Introduction to Bioinformatics Algorithms, MPI Press 2004.
2. D. W. Mont, Bioinformatics: Sequence and Genome Analysis, CSHL Press.
3. D. Gusfield, Algorithms on Strings, Trees, and Sequences: Computer Science and Computational Biology, Cambridge University Press, 1997.

CAM504B	Simulation and Modeling	Credits: 3

Simulation and its uses, Definition of System, Types of Systems, Simulation Experiments and Field Experiments, Random Number Generators from Uniform and other Continuous and Discrete Distributions, Tests of Randomness and Goodness of Fit.

Modeling Process and Concepts of Mathematical Models, Differential, Partial Differential and Difference Equation Models, Modeling through Graphs, Stochastic Models, Monte-Carlo Integration, Simulation of Single Server System, Inventory System, Time Sharing Computer System, and Ethernet Model. Verification, Validation and Comparison of Real System and Simulation Experiments Data, Variance Reduction Techniques, Simulation Languages: SIMULA, SIMSCRIPT and GPSS.

Suggested Readings:

1. J. A. Payne, Introduction to Simulation, Programming Techniques and Methods of Analysis, Tata McGraw Hill Publishing Co. Ltd.
2. A. M. Law, W. D. Kelton, Simulation Modeling and Analysis, McGraw Hill.
3. M. H. MacDougall, Simulating Computer Systems: Techniques and Tools, The MIT Press Cambridge.
4. Z. A. Klarian, EJ Dudewicz, Modern Statistical Systems and GPSS Simulation, Computer Science Press.
5. G. Gordon, System Simulation, PHI.
6. Narsingh Deo, System Simulation with Digital Computer, PHI.
7. JN Kapoor, Mathematical Modeling, Wiley Eastern Ltd.
8. BP Zeigler, H Praehofer, TG Kim, Theory of Modeling and Simulation-Integrating Discrete Event and Continuous Complex Dynamic Systems, Academic Press 2000.

CAM504C	Operation Research	Credits: 3

Network Analysis: Terminology of network, shortest route problem, minimal spanning tree problem, max-flow problem.

Project Scheduling by PERT, CPM: Diagram, representation, critical path calculation, construction of time chart and resource labeling, probability and cost consideration in project scheduling, project control.

Linear Programming: Simplex Method, Revised simplex method, Duality in Linear programming, Application of Linear Programming to Economic and Industrial Problems.

Nonlinear Programming: The Kuhn-Tucker conditions, Quadratic programming, Convex programming.

Replacement Models: Introduction, Replacement policies for items whose efficiency deteriorates with time, Replacement policies for items that fail completely.

Sequencing Model: Classification of self problems, processing of n jobs through two machines, three machines, processing of two jobs through m machines.

Suggested Readings:

1. Taha, Operations Research, Macmillan.
2. B.E. Gillet, Introduction to Operations Research, McGraw-Hill.
3. S.S.Rao, Optimization Theory and Applications, Wiley Eastern.
4. G.Hadley, Linear programming, Addison-Wesley.

CAM504D	Quantum Computing	Credits: 3

Introduction to Quantum Computing, Moore's Law, Limits from Bits to Qubits, Powers of Quantum Computing-Some Algorithms and Applications.

Qubits, Quantum Mechanics and Computer Science Perspectives. Quantum Gates, Applications of Quantum Computing, Shor's Algorithm and Quantum Fourier Transform, Quantum Search Algorithms, Physical Realization of Quantum Computers.

Suggested Readings:

1. Colin P. Williams, Scott H. Clearwater, Explorations in Quantum Computing, Springer.
2. Michael A. Nielsen, Isaac L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press.
3. Cris Calude, Gheorghe Paun, Computing with Cells and Atoms: An Introduction to Quantum, DNA and Membrane Computing, CRC.
4. Mika Hirvensalo, Quantum Computing, Springer.
5. Dirk Bouwmeester, Artur K. Ekert, Anton Zeilinger, The Physics of Quantum Information: Quantum Cryptography, Quantum Teleportation, Quantum Computation, Springer.
6. J. J. Sakurai, Modern Quantum Mechanics, Addison Wesley.

CAM504E	Introduction to Cryptography	Credits: 3

Divisibility, Euclidean Algorithm, Congruence's, Finite Fields, Quadratic Residues and Reciprocity, One-way and Trapdoor Functions, Stream Ciphers, Pseudo-Random Number Generators, Block Ciphers and Modes of Operations, Data Encryption Standard, Private Key Encryption, Public Key Encryption, RSA Cryptosystem, Rabin's Public Key Cryptosystem, Knapsacks, Message Authentication and Hash Functions, Digital Signatures, RSA Digital Signature Scheme, El Gamal's Scheme, Rabin's Scheme, Key Distribution, Diffie-Hellman Secret Key Exchange, Two-Party and Multi-Party Protocols, Simultaneous Secret Exchange Protocol, Secret Sharing.

Suggested Readings:

1. Bruce Schneier, Applied Cryptography: Protocols, Algorithms, and Source Code in C, Second E/d, John Wiley & Sons, 1996.
2. William Stallings, Cryptography and Network Security: Principles and Practice, Second Edition, Prentice Hall, 1998.
3. Neal Koblitz, A Course in Number Theory and Cryptography, Springer-Verlag.
4. A. J. Menezes, P. C. van Oorshot and S. A. Vanstone: Handbook of Applied Cryptography, CRC Press.
5. Shafi Goldwasser, Mihir Bellare, Lecture Notes on Cryptography. www.cse.ucsd.edu/~mihir/papers/gb.html
6. O. Goldreich, Foundations of Cryptography: Basic Tools, Cambridge University Press.

CAM504F	Advanced course in Software Engineering	Credits: 3

Software Metrics: Surveys, Experiment, Case studies, Internal and external software metrics, Reliability and quality metrics, Software management metrics.
Unified Modeling Language: Structure Diagrams: Class Diagram, Object Diagram, Component Diagram, Composite Structure Diagram, Package Diagram, and Deployment Diagram. Behavior Diagrams: Use Case Diagram (used by some methodologies during requirements gathering); Activity Diagram, and State Machine Diagram. Interaction Diagrams**:**Sequence Diagram, Communication Diagram, Timing Diagram, and Interaction Overview Diagram.
Software Reuse: Design patterns, Frameworks: development methodology, instantiation, CBSE.

Extreme Software Engineering approaches: Problems of traditional approaches, An agile process, Models of agile processes, Pair programming, Planning in an agile process, Testing in an agile process.

Software architecture: Architecture styles, Architecture Description Languages, Architecture frameworks

Suggested Readings:

1. Software Metrics- A Rigorous & Practical Approach, Fenton & Pleeger, International Thomson Computer Press.
2. Software Architecture- Perspectives on an Emerging Discipline, Shaw & Garlan, Prentice-Hall.
3. Design Patterns- Elements of Reusable Object-Oriented Software, Gamma, Helm, Johnson & Vlissides, Addison Wesley.
4. Extreme Programming And Agile Processes In Software Engineering, Jutta Eckstein, Hubert Baumeister, Springer, 2004.
5. UML- in a nutshell- A Desktop Quick Reference, Albir, O'Reilly.

CAM505	*Lab. Exercises based on course CAM501*	Credits: 3

This paper consists of programming exercises based on course CAM501: Parallel Computing.

CAM506	*Lab. Exercises based on course CAM502*	Credits: 3

This paper consists of programming exercises based on course CAM502: Internals of UNIX OS and Network Programming.

MCA- SEMESTER VI

CAM601	Dissertation	Credits: 18

Students will be required to pursue a dissertation allotted to them in accordance with their preference subject to their supervisor's approval. They will have to submit the dissertation done by them during the semester.

CAM602	Comprehensive Viva	Credits: 7

A Comprehensive Viva to judge students' overall academic attainments during the program.

M.Sc. ENVIRONMENTAL SCIENCE
Department of Botany
Banaras Hindu University

M.Sc. ENVIRONMENTAL SCIENCE
Special Course of study
Semesterwise Distribution of Courses and Credits

SEMESTER – I		
Courses	**Course Title**	**Credits**
ESM – 101	Foundation Course in Ecology	3
ESM – 102	Earth and its Atmosphere	4
ESM – 103	Aquatic Environment	3
ESM – 104	Energy Resources and Conservation	3
ESM – 105	*Lab work based on courses ESM – 101 to ESM – 102*	3
ESM – 106	*Lab work based on courses ESM – 103 to ESM – 104*	3
ESM – 107 M	Global Environmental Change (Minor Elective for Environmental Science and other PG programmes)	3
	Total	**22**
SEMESTER – II		
ESM – 201	Biodiversity and Conservation	3
ESM – 202	Environmental Microbiology and Biotechnology	3
ESM – 203	Environmental Pollution and Toxicology	3
ESM – 204	Environmental Monitoring and Management	3
ESM – 205	Environmental Legislation	3
ESM – 206	*Lab work based on courses ESM – 201 to ESM – 202*	3
ESM – 207	*Lab work based on courses ESM – 203 to ESM – 204*	3
ESM – 208M #	Environmental Conservation (Minor Elective for other PG programmes) Minor Elective (for Environmental Science students)	3
	Total	**24**
SEMESTER – III		
ESM - 301	Biostatistics, Modeling and Computer Applications	4
ESM – 302	Water Resource Management	3
ESM – 303	*Lab work based on courses ESM – 301 to ESM – 302*	3
ESM - 304 ESM - 305	*Any one of the following:* Ecological Restoration Society and Environment	3
ESM - 306 ESM - 307	*Any one of the following:* Air Pollution Control and Abatement Remote Sensing and GIS	3
ESM – 308	*Lab work based on courses ESM – 306/ESM – 307*	3
#	Minor Elective (for Environmental Science students)	3
	Total	**22**
SEMESTER – IV		
ESM – 401	Industrial Training Report**	8
ESM – 402	Dissertation based on project work	14
	Total	**22**
	Grand Total	**90**

Environmental Science students shall opt Minor Electives from other programmes
**Industrial training of 6 weeks during summer vacation following semester II

SEMESTER – I

ESM - 101: Foundation Course in Ecology

Organisms and environment: Holocoenotic nature of environment; abiotic and biotic environment; limiting factors; ecological amplitude.
Ecological adaptations: Morphological, anatomical and physiological responses of organisms to light, temperature, water and salinity; plant adaptations in relation to soil oligotrophy.
Population ecology: Population characteristics, population growth, carrying capacity, population regulation, life history strategies (*r* and K selection), population interactions including Lotka – Volterra model, population differentiation.
Community ecology: Concepts of community and continuum; community attributes; species diversity (α, β and γ); community coefficients; cluster analysis; ordination; concept of ecological niche.
Community development: Temporal changes (cyclic and non-cyclic); models and mechanisms of ecological succession; changes in ecosystem properties during succession.
Ecosystem organization: Ecosystem structure and functions, primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies); litter fall and decomposition; mineral cycles in terrestrial and aquatic ecosystems.
Ecosystem management: Concepts; sustainable development; sustainability indicators.
Biogeography: Life zones and major biomes; major vegetation and soil types of the world; bio-geographical regions of India; forest and grassland types of India.

ESM - 102: Earth and its Atmosphere

Weathering and erosion processes; Types and formation of soils and soil profile.
Geological work of rivers, glaciers, wind and ocean.
Causes, effects and control of earthquakes, volcanoes, landslides, floods and storms.
Major rock and ore forming minerals: Properties of minerals; Igneous, sedimentary and metamorphic rocks.
Impact of mineral exploration, mining, processing and utilization on environment.
Groundwater: Occurrence, chemistry; Salt water intrusion; Pollution and management.
Evolution of the earth's atmosphere, composition and thermal stratification, atmosphere and the earth's radiation balance, circulation of atmosphere, atmospheric stability, lapse rates and mixing heights, plume behaviour; Photochemistry of nitrogen oxides, oxygen, ozone and chlorides in the atmosphere.
Gaussian plume model, point source stream pollution model.
Climate and monsoon, Köppen's climate classification system; General relationship between landscape, biomes and climate.

ESM – 103: Aquatic Environment

Introduction to hydrosphere.
Chemistry of water; Hydrologic cycle; Diversity of aquatic habitats.
Aquatic food web and factors affecting primary productivity.
General characteristics of freshwater environment.
Lentic systems: Lakes-Origin and classification, ecological zonation, thermal stratification, water circulation, physical and chemical characteristics and biotic communities; Fertility and productivity; Brief account of ponds.
Lotic systems: Ecology of rivers and streams; River continuum concept.
General characteristics of marine environment.
Ocean: Chemistry of seawater, circulation and ecological zonation in sea, marine biota, primary productivity, coral reefs and marine resources.
Estuaries: Types, biotic communities and productivity; Environmental significance of estuaries; Mangroves.
Wetlands: Classification, range of productivity and ecosystem properties.
Eutrophication: Causes and consequences and methods of control.
Aquaculture: Current status, Indian scenario; Environmental impacts of aquaculture.

ESM – 104: Energy Resources and Conservation

Introduction: Energy, work and power; Energy and people; Energy sources – resource and reserves - an overview; An overview of the current global and National Energy Scenario.
Fossil fuels: Oil, coal, natural gas, shale, tar sands – sources, exploration, exploitation; environmental consequences.

Nuclear energy: Nuclear fission; nuclear minerals, nuclear fuel cycle, nuclear fuel production; nuclear reactors (PWR, BWR, Gas Cooled Breeder) and nuclear power, nuclear fusion; advantages and disadvantages of nuclear power; Environmental consequences – safety, terrorism, waste disposal and management.
Renewable and alternative energy sources: Solar energy and insolation, active and passive solar systems, solar power tower, photovoltaic cells; hydropower; tidal power; wind power; geothermal energy; ocean energy; fuel cells; environmental consequences, advantages and disadvantages.
Bio-energy: Biomass as energy source, biomass production; energy farming; biomass types and their characteristics; biomass conversion processes – Thermo-chemical and bio-chemical; thermo-chemical – combustion, gasification, liquefaction and pyrolysis of biomass; fermentation of biomass; anaerobic digestion of biomass and digester types; biodiesel; environmental consequences of biomass resource harnessing.
Energy storage and distribution: Importance; biological, chemical, electricity and heat storage; mechanical storage, distribution of energy.
Energy conservation: National energy policy, energy efficiency improvement, audit and energy saving.

ESM – 105: ***Lab work based on courses ESM – 101 to ESM – 102***

ESM – 106: ***Lab work based on courses ESM – 103 to ESM – 104***

ESM – 107M: Global Environmental Change (Minor Elective for Environmental Science and other PG programmes students)

Global Environmental change issues.
Depletion of stratospheric ozone layer, causes and effects of enhanced UV-B on biological systems and materials. Global efforts for mitigating ozone layer depletion.
Climate change: Palaeoperspective, recent trends and future projections; Greenhouse gases, sources, trends and impact on climate; Ecological impact of climate change; Greenhouse gas mitigation scenarios; International efforts on climate change issues.
Atmospheric depositions: Causes and consequences of excessive atmospheric deposition of nutrients and trace elements; Eutrophication; Acid rain and its effect on organisms and ecosystems; Problems of acid rain in India.

SEMESTER – II

ESM – 201: Biodiversity and Conservation

Introduction to biodiversity: species, genetic, community and ecosystem diversity.
Biodiversity magnitude and distribution: speciation and build-up, diversity gradients and related hypotheses, biodiversity and ecosystem function, methods for biodiversity monitoring.
Biodiversity and ecosystem services: provisioning, regulating, cultural and supporting.
Threats to biodiversity: natural and anthropogenic, species extinctions, IUCN threat categories, Red data book, Invasions: causes and impact.
Biodiversity conservation, principles and strategies; *in-situ* and *ex-situ* conservation, Protected Area Network; Convention on biological diversity, Biodiversity Act., NBSAP
Mega diversity zones and Hot spots: concepts, distribution and importance.
Use of biodiversity: Source of food, medicine, raw material, aesthetic and cultural.
Biodiversity prospecting.

ESM – 202: Environmental Microbiology and Biotechnology

Introduction to microorganisms: General characteristics, nutritional types, microbial diversity.
Tools and techniques for exploration of microorganism.
Types of interaction between plants and microbes.
Microorganisms and soil fertility, nutrient cycling.
Microorganisms in extreme environments.
Microbial toxins and environmental hazards.
Brief account of plant diseases and their ecosystem level effects.
Microbes and public health: Brief account of microbial diseases and their control.
Microbially induced corrosions and biofilms.
Microbes and environmental protection: Bioremediation of organic and inorganic contaminants; waste water treatment, microorganisms as regulator of atmospheric trace gases.
An introduction to environmental biotechnology.

Brief account of restriction enzymes, cloning vectors, DNA ligases, linkers, blotting techniques and gene libraries.
Strategies of recombinant DNA technology and its applications including waste treatment and environmental restoration.
Selection of nutritional quality, disease resistance and salt and drought tolerance
Release of genetically engineered organisms and environmental risk.
Vermicular and bio-fertilizer technology.

ESM – 203: Environmental Pollution and Toxicology

Air pollution: Types and sources, Effects of SO_2, NO_2, O_3, HF, photochemical smog, acid rain and particulates on plants, animals and human health, aeroallergens and allergies.
Ozone layer depletion: Causes and consequences.
Noise pollution: Types, sources and effects on human health.
Water Pollution: Types and sources; Effects on water quality, plants and human health; Thermal pollution.
Soil pollution: Types and sources, Effects of pesticides and heavy metals on ecosystems, mechanisms of metal toxicity, metallophytes.
Radioactive pollution: Sources and hazards.
Solid waste: Sources and effects.
Toxicology: Principles, dose-response relationships, toxicity testing, persistence of pesticides and bio-magnification.
Uptake, bioaccumulation, bio-transformation and excretion of xenobiotics.
Role of temperature and humidity in human health.
International programme on chemical safety.

ESM – 204: Environmental Monitoring and Management

Methods of collection and analyses of gaseous and particulate pollutants, Stack monitoring.
Methods of collection of water samples and analyses of physico-chemical characteristics.
Methods of collection of soil samples and analyses of physico-chemical characteristics.
Bio-monitoring and bio-indication.
Principles of chromatography, spectrophotometry, electro-analytical and radio-analytical techniques.
Environmental Management: concept and strategies.
Environment and sustainable development, indicators, economic valuation of environmental resources.
Environmental Management System (EMS): ISO-14000, EMS-audit, Environmental clearance for establishing industries.
Environmental Impact Assessment (EIA); EIA guidelines 1994, Environmental impact analysis and statement, Environmental cost-benefit analysis and fiscal incentives.
International efforts on environmental management, Intellectual property rights (IPRs), Corporate environmental ethics.

ESM – 205: Environmental Legislation

Historical background of Environmental Law and Policy in India.
Constitutional mandate for environmental protection
The Water (Prevention and Control of Pollution) Act, 1974; Meaning of water pollution; Enforcement authorities and their functions; Pollution control mechanism; Cognizance of offences and penalties.
The Air (Prevention and Control of Pollution) Act, 1981; Meaning of air pollution; Enforcement authorities and their functions; Pollution control mechanism; Cognizance of offences and penalties.
The Environmental (Protection) Act, 1986; Meaning of Environment, hazardous substance and pollution; Enforcement authority and its powers; Pollution control mechanism; Cognizance of offences and penalties, Ecomark.
The Public Liability Insurance Act 1991: Liability principles; Relief; Procedure to claim relief; Penalties.
Salient features of the following Acts and Rules:
(a) The Wild Life Protection Act, 1972
(b) The Forest Conservation Act, 1980
(c) The Biodiversity Act, 2002
(d) The Hazardous Wastes (Management and Handling) Rules, 1989
(e) The Noise Pollution (Regulation and Control) Rules, 2000

(f) The Indian Panel Code, 1860 and The Code of Criminal Procedure, 1973

ESM – 206: ***Lab work based on courses ESM - 201 to ESM – 202***

ESM – 207: ***Lab work based on courses ESM – 203 to ESM - 204***

ESM – 208M: Environmental Conservation (Minor Elective for students of other PG programmes)

Air environment: Air quality standards, air pollutant sources, health effects and control, acid rain and its impact.
Aquatic system: Water quality standards, water pollutant sources, health effects and control, eutrophication and its control, watershed management, rain water harvesting.
Biodiversity: Importance, threats, approaches for conservation and management of biodiversity.
Soil: Soil resources in relation to food, feed, and fibre needs, soil fertility and need for agricultural sustainability; Soil conservation and erosion control; Restoration of damaged and contaminated soils.
Energy: Basics of energy and its various forms; Energy management and audit.

SEMESTER - III

ESM – 301: Biostatistics, Modeling and Computer Application

General concepts and terminology; sampling methods; distribution of attributes; tests of hypothesis and significance; contingency tables and chi-square test; comparison of means: t-test, multiple range tests; Simple experimental design and analysis of variance; correlation and regression analysis; Introduction to multivariate methods.
Approaches to development of models; conceptual, statistical and mathematical models; steps in the modeling process; single and multiple regression models; modeling coupled human-natural systems; model testing and validation; models as predictive tools.
Basic concepts of computer hardware; operating systems-Windows, Unix and Linux; use of common application software in biology: word processing, spreadsheets, graphics and database; introduction to web browsing software and search engines with special reference to online bioscience resources.

ESM – 302: Water Resource Management

Global distribution of water resources, water need and consumption; Threats to surface water resources; Principles and approaches to surface water management.
Watershed management: Catchment infiltration models, rain water harvesting and storage, recharging of ground water; Role of dams.
Properties of sewage and industrial effluents; Effluent standards; Treatment of industrial effluents, sewage treatment (primary, secondary and tertiary treatment), advanced treatments (nitrate and phosphate removal); Sludge treatment and disposal; Waste water use.
Drinking water quality and water treatment (desalination, ion-exchange, reverse osmosis and disinfection of water).
Management of degraded water resources.
People's participation and mass awareness programmes for water resource management.

ESM – 303: ***Lab work based on courses ESM – 301 to ESM – 302***

Any one of the following: **(ESM-304 and ESM-305)**

ESM – 304: Ecological Restoration

Definitions and concept, reclamation, remediation, restoration and rehabilitation.
Disturbance: causes and impact on the structure and functioning of terrestrial and aquatic ecosystems.
Aims and strategies: Passive and active; habitat, species and ecosystem restoration; single vs. multiple end-points.
Ecosystem reconstruction: Acceleration of ecological succession, physical, chemical, biological and biotechnological tools.
Restoration of biological diversity: Augmentation, reintroduction and introduction of species.
Degradation and Restoration of natural ecosystems: Forests, grassland/savanna, wetlands and other aquatic ecosystems.

Restoration of degraded soils: Restoration of contaminated soils and soil fertility, mine spoil restoration.

ESM – 305: Society and Environment

Social perspectives of environment: Global and Indian issues.
Social impacts of growing human population and affluence, production and distribution of food, hunger, poverty, malnutrition, famine.
Social impacts of water crisis, global climate change, O_3 depletion, nuclear accidents, acid rain, consumerism and waste products.
Problems related to major dams and other developmental projects, resettlement and rehabilitation.
Environment and human health: epidemiological issues, women and child welfare, family welfare programme.
Environmental education, value education, public awareness, peoples participation in resource conservation and environmental protection, Environmental ethics.
Social perspectives of sustainable development.

Any one of the following: **(ESM-306 and ESM-307)**

ESM: 306: Air Pollution Control and Abatement

Air quality criteria and standards, air pollution indices; National Environment policy; National air monitoring programme.
Control of inorganic emissions, clean coal technology, coal conversion, industrial clean-up technology.
Air pollution control equipments: settlers, cyclone collectors, air filters, scrubbers and electrostatic precipitators.
Control of CO, SO_2, NOx and VOCs emissions, control of vehicular emission.
Indoor air quality control.
Biological abatement of air pollution, scope of green belt development, phytoremediation.
Noise pollution: Standards, abatement and control.
Economic aspects of air pollution control.

ESM – 307: Remote Sensing and GIS

Fundamentals of remote sensing; Principles of electromagnetic radiation and EM spectrum.
Sensors and platforms; remote sensing satellites, multispectral, hyperspectral and thermal sensors; RS data acquisition systems.
Image processing; Image enhancement and visualization; Image interpretation and classification.
Microwave thermal remote sensing; Radar & laser altimetry.
Applications of Remote Sensing; Integration of remote sensing and GIS.
Basic concepts of GIS; cartographic principles, map projections and coordinate systems.
Geographic information and spatial data types; Hardware and software; Steps of spatial data handling; Database management systems; Spatial referencing.
Data quality, measures of location errors on maps.
Spatial data input, data preparation; Point data transformation.
Analytical GIS capabilities, retrieval and classification, overlay functions.
Neighborhood operations, network analysis, error propagation; Data visualization.

ESM –308: ***Lab work based on ESM – 306/ESM – 307***

 # Minor Elective: Environmental Science students shall opt from other programmes

SEMESTER – IV

ESM – 401: Industrial Training Report

Students are required to go for Industrial training (8 credits) of six weeks during summer vacation after completion of semester II examination. The training will be evaluated during semester IV on the basis of a report and seminar.

ESM – 402: Dissertation based on project work

The project work (14 credits) will be carried out by the students in semester IV and work will be evaluated on the basis of dissertation and seminar.

CENTRE FOR ENVIRONMENTAL SCIENCE & TECHNOLOGY
Faculty of Science
Banaras Hindu University

M. Sc. (Tech.): Environmental Science and Technology

M. Sc. (Tech.) in Environmental Science and Technology

ELIGIBILITY REQUIREMENTS (*QUALIFYING EXAMINATION*)

Candidates who have passed B.Sc. (Hons.) /B.Sc. (10+2+3) or B.Sc. (Ag) or M.B.B.S. or BE/B. Tech. with a minimum of 50% marks (equivalent GPA with a minimum 50% aggregate at 10 & 10+2 levels) shall be considered for admission to ***M. Sc. Tech. in Environmental Science and Technology***.

GENERAL GUIDELINES

- There shall be six semesters of 135 credits.
- In first, second and third semesters, there shall be 4 theory, 1 minor elective & 2 practical (3 credits for each theory & minor elective and 4 credits for practical).
- In forth semester there shall be 6 major elective courses (each of 4 credits) out of which 4 has to be opted by the student and 1 dissertation of 5 credits.
- In fifth semester there shall be Industrial tour (8 credits), industrial training (10 credits) and presentation of industrial tour & training report (5 credits).
- In sixth semester there shall be 4 major elective courses (each of 4 credits) out of which 2 has to be opted by the student and a project work of 10 credits & a seminar presentation based on project work (4 credits).

M.Sc. (Tech.) in Environmental Science & Technology

Semesterwise distribution of Courses and Credits

SEMESTER-I		
Course Code	**Title**	**Credits**
ETM101	Basics of Environmental Science & Technology	3
ETM102	Computer Application & Statistics	3
ETM103	Environmental Pollution and management	3
ETM104	Geoinformatics	3
ETM105	Lab exercises based on ETM101 & ETM102	4
ETM106	Lab exercises based on ETM103 & ETM104	4
ETM107M	Natural Hazards (Minor elective for the students of ES & T only)	3
	Total	**23**
SEMESTER-II		
ETM201	Environmental Monitoring Technologies	3
ETM202	Environmental Biotechnology	3
ETM203	Ecological Engineering	3
ETM204	Chemical Hazards & Management Technologies	3
ETM205	Lab exercises based on ETM201 & ETM202	4
ETM206	Lab exercises based on ETM203 & ETM204	4
ETM207M	Socio-economic Dimensions of Environmental Management (Minor elective for the students of ES & T only)	3
	Total	**23**
SEMESTER-III		
ETM301	Waste Management Technologies	3
ETM302	Air Monitoring & Management	3
ETM303	Water Management	3
ETM304	Mining Environment & Management	3
ETM305	Lab exercises based on ETM301 & ETM302	4
ETM306	Lab exercises based on ETM303 & ETM304	4
ETM307M	Bio-resource Management (Minor elective for the students of ES & T only)	3
	Total	**23**

SEMESTER-IV (Any four major electives from the ETM401 - ETM406)		
Course Code	**Title**	**Credits**
ETM401	Global Energy Scenarios & Non-Conventional Energy	4
ETM402	Climate Change & Abatement Technologies	4
ETM403	Environmental Legislation and Impact Assessment	4
ETM404	Noise Pollution & Abatement Technologies	4
ETM405	Technologies for Restoration of Degraded Soils	4

ETM406	Biodiversity Conservation	4
ETM407	Dissertation based on selected papers	5
	Total	**21**
SEMESTER-V		
ETM501	Industrial Tour (study of different kinds of industries)	8
ETM502	Industrial Training (technical training in any industry)	10
ETM503	Presentation of Industrial Tour & Training Report	5
	Total	**23**
SEMESTER-VI (Any two major electives from the ETM601 - ETM604)		
ETM601	International Agreements on Environment	4
ETM602	Environmental Modelling	4
ETM603	Industrial Ecology	4
ETM604	Environmental Economics	4
ETM605	Project Work (Project on any Environmental Issue)	10
ETM606	Seminar based on project	4
	Total	**22**
	Grand total	**135**

SEMESTER-I

ETM101: Basics of Environmental Science & Technology **Credits: 3**

Basic concepts of environmental science & technology, major issues and challenges
Origin of earth, composition of atmosphere, lithosphere, hydrosphere, biosphere and natural resources
Ecosystem structure : air, water, soil, primary producers, consumers and decomposers
Ecosystem function : energy flow, food chains, food webs, ecological pyramids & biotic interaction
Ecosystem disturbance, resilience, decline & succession
Global environmental changes
Decline of biodiversity, its reason and consequences of loosing bio-diversity.
Concepts of sustainable development
Ethics of stewardship
Scope of environmentally sound technologies

ETM102: Computer Application & Statistics **Credits: 3**

Basic concepts of computer, hardware, operating systems: Windows, Unix and Linux
Use of common application software in biology: word processing, spreadsheets, graphics and data base
Introduction to web browsing software and search engines
Introduction to sampling methodology
Measures of central tendency and graphical representation of data
Contingency tables and chi-squire test
Difference between sample means: t-test, range tests
Correlation measurements and regression analysis
Simple experimental design and analysis of variance
Introduction to multivariate methods

ETM103: Environmental Pollution and Management **Credits: 3**

Types, major sources and effects of air pollutants, air borne diseases
Technologies for air pollution management
Types, major sources and effects of water pollutants, water borne diseases
Technologies for water pollution management
Types, major sources and effects of soil pollutants
Technologies for soil pollution management
Major sources of noise pollution, effects of noise pollution on health
Technologies for noise pollution management
Types, major sources and effects of radioactive pollutants
Air, water and noise quality standards

ETM104: Geoinformatics **Credits: 3**

Geographic Information Systems
Map Projections
Surveying
Understanding geographic data
Global Positioning Systems
Photogrammetry Methods
Remote Sensing of environment
Digital Image Processing
Digital Cartography
Application of GIS and remote sensing in environmental monitoring and management

ETM105: Lab exercises based on ETM101 & ETM102 **Credits: 4**
ETM106: Lab exercises based on ETM103 & ETM104 **Credits: 4**
ETM107M: Natural Hazards (Minor elective for the students of ES & T only) **Credits: 3**

Extent and nature of natural hazards
Nature and extent of flood; environmental effects of flooding; flood mitigation methods

Landslides: causes, prevention and correction

Coastal hazards: tropical cyclone and tsunamis; coastal erosion; sea level changes and its impact on coastal areas, hurricanes and tsunami

Earthquakes: causes, intensity and magnitude of earthquakes, geographic distribution of earthquake zones, nature of destruction, protection from earthquake

Volcanism: nature, extent and causes of volcanism, geographic distribution of volcanoes, volcanism and climate

Disaster management Technologies: pre-disaster phase, actual disaster phase, post-disaster phase

Technological assistance for disaster management

Relief camps, organization, camp layout, food requirement, water needs, sanitation, security, information administration

Role of NGOs in disaster management

Semester-II

ETM201: Environmental Monitoring Technologies **Credits: 3**

Meteorological monitoring technologies

Application of remote sensing for environmental monitoring

Vegetation mapping and monitoring of biodiversity

Optical and Molecular Spectroscopy

Non-Optical Spectroscopes

Physical and Chemical Sensors

Chromatographic and Partition Techniques

Chemical sensors

Biosensors

Biological Methods of environmental monitoring: Microbial Screening, DNA Probes, Bioassays

ETM202: Environmental Biotechnology **Credits: 3**

Basic techniques in genetic engineering: Nucleic acid hybridisation and polymerase chain reaction as sensitive detention methods

Introduction of clone genes into new hosts using plasmid and phage vector systems. Expression of genes in new host

Use of micro-organisms in waste treatment and methane production

Production of microbial enzymes: cellulase, proteases, amylases

Alcohol and acetic acid production

Microbial leaching of low grade mineral ores

Molecular probes for organisms in mines and mine tailings

Biodegradation of petroleum pollutants

Biofiltration technologies for pollution abatement

Genetically engineered microbes and environmental risk

ETM203: Ecological Engineering **Credits: 3**

Ecological engineering as a tool for restoration of degraded ecosystems

Ecology of Disturbed Ecosystems: disturbance and its impact on the structure and functioning of terrestrial and aquatic ecosystems.

Concepts and strategies of restoration

Biological and biotechnological tools of restoration

Restoration of biological diversity: Acceleration of ecological succession, reintroduction of biota

Degradation and restoration of Forests ecosystems

Degradation and restoration of grassland ecosystems

Degradation and restoration of aquatic ecosystems

Degradation and restoration of wetlands

Restoration of wastelands and degraded soils: Restoration of contaminated soils and soil fertility, mine spoil restoration

ETM204: Chemical Hazards & Management Technologies **Credits: 3**

Toxicity of chemicals and its dose effect relationships

Chemical hazards in air, water & soil and remedial measures

Monitoring and control of chemical hazards

Characteristics and hazards of radioactive materials, dispersion of radioactive materials

Risk assessment techniques for accidental release of toxic and inflammable materials

Occupational health hazards: Silicosis, asbestosis, bronchitis, heart disease, nasal cancer

Industrial chemical hazards and safety measures

Biochemical effects of toxic heavy metals, pesticides, carcinogens, mutagens and teratogens

Food adulteration, contaminations and related hazards

Handling and transport of hazardous materials, environmental safety, risk management and emergency preparedness

ETM205: Lab exercises based on ETM201 & ETM202 **Credits: 4**

ETM206: Lab exercises based on ETM203 & ETM204 **Credits: 4**

ETM207M: Socio-economic Dimensions of Environmental Management (Minor elective for the students of ES & T only) **Credits: 3**

Population explosion and social factors affecting development - poverty, affluence, education, employment, child marriage and child labour

Environment and human health, human rights, value education, women and child welfare

Impact of development on environment - changing patterns of land use, land reclamation, deforestation, resource depletion, pollution and environmental degradation

Basic concepts of sustainable development and social environmental issues

Community participation and capacity building programmes for sustainable socio-economic and ecological development

Role of NGOs in environmental awareness and management

Role of media in environmental awareness and management

Semester-III

ETM301: Waste Management Technologies **Credits: 3**

Sources of waste, types and characteristics

Sewage disposal and its management

Solid waste disposal

Biomedical waste handling and disposal

Nuclear waste handling and disposal

Waste from thermal power plants, reuse and disposal

Waste minimization in industries, recycling and disposal technologies

Role of Microbes in waste minimization

Bio-chemistry of anaerobic fermentation and design of biogas systems

Application of phytoextraction and biofilteration techniques for waste management

ETM302: Air Monitoring and Management **Credits: 3**

Basic principles of air pollution management

Ambient concentrations of air pollutants and trace gases

Air pollution and human health

Vehicular pollution, monitoring and abatement technologies

Meteorological parameters and dispersal of air pollutants

Air pollution control equipments

Control of particulate emission

Control of sulphur oxide and nitrogen oxides

Indoor air pollution and its control

Biological abatement of air pollution

ETM303: Water Management **Credits: 3**

Global distribution of water, hydrological cycle and water balance on earth

Physico-chemical and biological properties of fresh water and water quality standard

Major sources of water pollution and its effect on surrounding water bodies

Effects of water pollutants on primary productivity of water bodies

Treatment technologies for domestic and industrial waste waters

Biological treatment of waste waters

Ozonization of secondary treated waste water

Ground water resources and its management

Water management strategies: rain water harvesting, artificial recharging of ground water and use of domestic and industrial waste waters

Watershed development, river linking and hydro power projects

ETM304: Mining Environment & Management **Credits: 3**

Mining types and major environmental issues

Classification and properties of rocks

Classification and properties of minerals

Metallic and non-metallic mineral deposits

Geological and geographical distribution of mineral resources

Importance of mining and mineral resources

Impact of mining activities on health

Mine waste disposal and related problems

Mitigation technologies for mining related environmental problems

Restoration of mined areas

ETM305: **Lab exercises based on ETM301 & ETM302** **Credits: 4**

ETM306: Lab exercises based on ETM203 & ETM304 **Credits: 4**

ETM307M: Bio-resource Management Technologies **Credits: 3**

(Minor elective for the students of ES & T only)

Status and strategies for bioresource management

Sustainable exploitation and development

Forest resources management, social forestry and agro forestry

Grassland management

Cropland Management

Freshwater bioresource management

Marine bioresource management

Wetlands and estuary bioresource management

Microbial resource management

Wildlife management

Semester-IV

(ANY FOUR MAJOR ELECTIVES FROM THE etm401 - etm406)

ETM401: Global Energy Scenarios & Non-Conventional Energy **Credits: 4**

Global patterns of energy consumption, rising demand and supply

Conventional energy sources, potential and limitations, methods of harnessing and environmental consequences

Types of non-conventional energy sources, potential and limitations, methods of harnessing and their environmental consequences

Energy Conservation- efficiency in production, transportation and utilization of energy

Future sources of energy: hydrogen, alcohol, biodiesel, fuel cells

ETM402: Climate Change & Abatement Technologies **Credits: 4**

Greenhouse gases and global warming
Drought and desertification
Acid rain and abatement technologies
Ozone layer destruction and prevention
Technologies to minimize and combat climate change

ETM403: Environmental Legislation & Impact Assessment **Credits: 4**

Powers and functions of Central & State pollution control boards
Duties and responsibilities of citizens for environmental protection
Important legislations related with environment: Wildlife Protection Act 1972, The Water (Prevention and Control of Pollution) Act 1974. Prevention and Control of Air Pollution Act 1981, Forest Conservation Act 1981, Environment (protection) Act 1986, Hazardous waste (Management and Handling) Rules, 1989, Bio-Medical Waste (Management and Handling) Rules, 1998
Environmental Impact Assessment (EIA), Environmental impact statement (EIS), Environmental management plan (EMP) and Environmental clearance for establishing industry
Cost benefit analysis, Environmental audit, ISO 14000 standards and certification

ETM404: Noise Pollution & Abatement Technologies **Credits: 4**

Noise pollution sources
Ambient noise level and its monitoring
Noise standards
Biological and behavioural effects of noise pollution
Noise pollution control technologies: physical and biological approaches

ETM405: Technologies for Restoration of Degraded Soils **Credits: 4**

Physico chemical and biological properties of soil
Soil forming factors and soil development
Land use classification
Soil Erosion, factors affecting erosion
Principles and methodologies for soil conservation and restoration

ETM406: Biodiversity Conservation **Credits: 4**

Biodiversity trends, diversity gradients and related hypotheses methods for monitoring biodiversity trends
Mega diversity zones and hot spots
Biodiversity valuation, goods and services provided by biodiversity
Threats to biodiversity, major causes, extinctions, vulnerability of species to extinction, IUCN threat categories, Red data book
Principles and strategies of biodiversity conservation

ETM407: Dissertation based on selected papers. **Credits: 5**

Semester-v

ETM501:	**Industrial Tour (study of different kinds of industries)**	**Credits: 8**
ETM502:	**Industrial Training (technical training in any industry)**	**Credits:10**
ETM503:	**Presentation of Industrial Tour & Training Report**	**Credits: 5**

Semester-VI

(Any two major electives from the ETM601 - ETM604)

ETM601: International Agreements on Environment **Credits: 4**

Global organizations working on ecology and environmental issues
United Nations Conference on Human Environment - UNCHE (Stockholm, 1972).

United Nations Conference on Environment and Development - UNCED (Rio de Janeiro, 1992)
World Summit on Sustainable Development - WSSD (Johannesburg, 2002)
Treaties/protocols related with environment

ETM602: Environmental Modelling **Credits: 4**

Basic concept of environmental modeling, its scope and limitations
Air quality modelling
Surface and ground water quality modelling
Modelling of hazardous substances
Modelling for landscape and urban planning

ETM603: Industrial Ecology **Credits: 4**

Industrial ecology and ssustainable industry concept
Life Cycle Assessment, Inventory analysis and input/output techniques, applying LCA for eco labeling & solid waste management
Product design and development – design for environment
Material flow analysis and dematerialization, servicizing and consumption
Environmental management systems, greening supply chains, and life cycle management

ETM604: Environmental Economics **Credits: 4**

World environmental history and economic development
Valuation of natural resources
Sustainable agriculture and development
Cost benefit analysis and integrated economic modelling
Environmental indicators and their use in resource management

ETM605: Project Work (Project on any Environmental Issue) **Credits:10**

ETM606: Seminar based on project **Credits: 4**

M.A. / M. Sc. GEOGRAPHY
Department of Geography
Banaras Hindu University

M.A. / M.Sc. GEOGRAPHY
Semesterwise distribution of Courses and Credits

I SEMESTER

GMC 101	Theory (core) 1	Emerging Geographical Thought	4
GMC 102	Theory (core) 2	Physical Landscape and Hydrology	4
GMC 103	Theory (core) 3	Advanced Geography of India	4
GMP 104	Practical (core)	1. Physical Diagrams, Hydrology and Map Projections	3
GMP 105	Practical (core)	2. Spatial Analysis: Locational and Network	3
GMM 501	Elective (Minor)	1. Remote Sensing Basics	3
GMS 601	Seminar (Core)	Assignment- Based Seminar: 1	2
	TOTAL	**I SEMESTER**	**23**

II SEMESTER

GMC 106	Theory (core) 4	Advanced Geomorphology	4
GMC 107	Theory (core) 5	Geography of Resources	4
GMP 108	Practical (core)	3. Statistical Methods and Data Processing	3
GME 201 GME 301 GME 401	Elective (Major): 1 Special Group	Special Group Theory Papers, One of the following: Gr. I: 1. Population Geography Gr. II: 1. Resource Planning Gr. III: 1. Advanced Cartography	4
GMP 202 GMP 302 GMP 402	Practical : 1 Elective (Major)	Special Group Practical, Elective, One of the following: Gr. I: 1. Population Geography Gr. II: 1. Resource Planning Gr. III: 1. Advanced Cartography	3
GMM 502	Elective (Minor)	2. Population and Development	3
GMS 602	Seminar (Core and Major Elective)	Assignment- Based Seminar : 2	2
	TOTAL	**II SEMESTER**	**23**

III SEMESTER

GMC 109	Theory (core) 6	GIS and Its Application	4
GMC 110	Theory (core) 7	Environmental Studies	4
GMP 111	Practical (core)	4. Remote Sensing and GIS; Soil, Water and Air Analysis	3
GMF 701	Field Training	Field Study and Geographical Excursion (**Duration**: 2-3 weeks; **Area, India**: South / Northwest / North)	2
GME 203 GME 303 GME 403	Elective (Major): 2 Special Group	Special Group Theory Papers, One of the following: Gr. I: 2. Geography of Rural Settlements Gr. II: 2. Regional Planning Gr. III: 2. Aerial Photo Interpretation.	4
GMP 204 GMP 304 GMP 404	Practical: 2 Elective (Major)	Special Group Practical, Elective, One of the following: Gr. I: 2. Geography of Rural Settlements Gr. II: 2. Regional Planning Gr. III: 2. Aerial Photo Interpretation and GIS	3
GMM 503	Elective (Minor)	3. Resources and Environmental Management	3
GMS 603	Seminar (Core and Major Elective)	Assignment- Based Seminar: 3	2

	TOTAL	**III SEMESTER**	**25**

IV SEMESTER

GMC 112	Theory (core) 8	Interdisciplinary Research Methods and Techniques	4
GME 205 GME 305 GME 405	Elective (Major): 3 Special Group	Special Group Theory Papers, One of the following: Gr. I: 3. Urban Geography Gr. II: 3. Rural and Urban Planning Gr. III: 3. Satellite Image Interpretation.	4
GMP 206 GMP 306 GMP 406	Practical: 3 Elective (Major)	Special Group Practical, Elective, One of the following: Gr. I: 3. Urban Geography Gr. II: 3. Rural and Urban Planning Gr. III: 3. Satellite Image Interpretation	3
GMS 604	Seminar (Core and Major Elective)	Assignment- Based Seminar : 4	2
GMF 702	Field Survey	Instrumental and Socio-economic (2+2 Credits)	4
GMD 703	Dissertation	Field Work Dissertation and Viva Voce: (4 + 2 Credits)	6
	TOTAL	**IV SEMESTER**	**23**

I to IV Semesters:
(1) Departmental CORE Courses (58 credits):
--Theory: 8 (each 4 credits), i.e. 32; Practical: 4 (each 3 credits), i.e. 12 = 44 credits.
--Assignment based Seminar (Core and Major Elective): 4 (each 2 credits) = 8 credits.
--Field Study and Geographical Excursion: = 2 credits.
--Field Survey: Instrumental and Socio-economic: = 4 credits.

(2) Major Elective (Specialisation; 27 credits):
--Elective (Major) Special Group, Theory: 3 (each 4 credits) = 12 credits.
--Elective (Major) Special Group, Practical: 3 (each 3 credits) = 9 credits.
--Dissertation: Field Work Dissertation and Viva Voce: 4+2 = 6 credits.

(3) Elective (Minor) Theory: 3 (each 3 credits) = 9 credits

TOTAL **94**

SPECIALISATION GROUPS

I. Population and Settlement Geography.
II. Applied Geography and Planning.
III. Cartography and Remote Sensing.

MINOR ELECTIVE: All the three **minor elective papers** offered by the department may be taken by the students of Geography as well as by the students of other M.Sc. courses

GMC 101. Theory (core), Paper: 1.
Emerging Geographical Thought

UNIT I

Basic Frame and Concepts. Man-environment interaction: New environmentalism; Concepts: space, place, environment, time, and spatial organisation; Region and regional typology; Culture and cultural landscape.

UNIT II

Modern Approaches. Quantitative revolution and challenges; Philosophy and geography: Contributions of Vidal de la Blache, and Carl Sauer; Humanistic and phenomenological geography: contributions of Yi-Fu Tuan; Literary geography: landscape as text.

UNIT III

Contemporary Trends. Qualitative paradigm; Behavioural revolution: perception and cognition, mental maps; Marxism; Postmodernism; Poststructuralism and Postcolonialism.

UNIT IV

Indian Geography: Base and Trends. Postcolonialism and Indian geography; Gandhi's contribution and Indian geography; Gaia theory and links to Indian literature; Ancient Indian geography and scientific outlook (e.g. cultural astronomy); Future of Indian geography: problems, perspectives and prospects.

Books Recommended

1. Adams, P., Steven, H. and Karel, T. (eds.) (2001): Texture of Place. Exploring Humanistic Geographies. University of Minnesota Press, Minneapolis.
2. Anderson, K., Domosh, M., Pile, S. and Thrift, N. (eds.) (2003): Handbook of Cultural Geography. Sage Publications, London.
3. Barnes, T. and Gregory, D. (eds.) (1997): Readings in Human Geography: The Poetics and Politics of Inquiry. Arnold, London.
4. Bunkše, E. V. (2004): Geography and the Art of Life. John Hopkins University Press, Baltimore.
5. Buttimer, A. (1971): Society and Milieu in the French Geographic Tradition. Rand McNally, Chicago.
6. Daniels, P., Bradshaw, M., Shaw, D. and Sidaway, J. (2000): An Introduction to Human Geography. Issues for the 21st Century. Prentice Hall, London.
7. Dear, M. J. and Flusty, S. (2002): The Spaces of Postmodernity: Readings in Human Geography. Blackwell Publishers, Oxford.
8. Dikshit, R. D. (2004): Geographical Thought. A Critical History of Ideas. Prentice-Hall of India, New Delhi. (in English and Hindi).
9. Doel, M. (1999): Poststructuralist Geographies. The Diabolical Art of Spatial Science. Edinburgh University Press, Edinburgh
10. Gaile, G. and Wilmott, C. (eds.) (2003): Geography in America at the Dawn of the 21st Century. Oxford University Press, Oxford and New York.
11. Harvey, D. (1969): Explanation in Geography. Arnold, London.
12. Harvey, M. E. and Holly, P.B. (2002): Themes in Geographic Thought. Rawat Publications., Jaipur and New Delhi.
13. Hubbard, P., Kitchin, R., Bartley, B. and Fuller, D. (2002): Thinking Geographically: Space, Theory and Contemporary Human Geography. Continuum, London.
14. Johnston, R., Gregor, D., Pratt, G, Watts, M. and Whatmore, S. (2003): The Dictionary of Human Geography. Blackwell Publishers, Oxford. 5th edition.
15. Johnston, R.J. (1985): The Future of Geography, Metheun and Company Ltd., New York. (2003 edition published).
16. Johnston, R.J. and Sidaway, J.D. (2004): Geography and Geographers. 6th edition, Edward Arnold, London.
17. Kapur, A. (ed.) (2001): Indian Geography – Voice of Concern. Concept Publishing. Company, New Delhi.
18. Martin, G. (2005): All Possible Worlds. A History of Geographical Ideas. 4th edition, Oxford University Press, New York.
19. Mathews, J. A. and Herbert, D. T. (eds.) (2004): Unifying Geography. Common Heritage, Shared Future. Routledge, London.
20. Peet, R. (1998): Modern Geographical Thought. Blackwell Publishers Inc, Massachusetts.
21. Sack, R. D. (ed.) (2002): Progress. Geographical Essays. John Hopkins University Press,

Baltimore.
22. Sauer, C. O. (1963): Land and Life. University of California Press, Berkeley.
23. Singh, R. L. and Singh, Rana P.B. (eds.) (1990): Literature and Humanistic Geography. National Geographical Society of India, BHU, Varanasi, Publication number 37
24. Singh, R. L. and Singh, Rana P.B. (eds.) (1992): The Roots of Indian Geography: Search and Research. National Geographical Society of India, B.H.U., Varanasi, Publication number 39.
25. Singh, Rana P.B. (ed.) (1993): Environmental Ethics. National Geographical Society of India, BHU, Varanasi, Publication number 40.
26. Singh, Rana P.B. (ed.) (1994): The Spirit and Power of Place. National Geographical Society of India, BHU, Varanasi, Publication number 41.
27. Singh, Rana P. B. (2004): Cultural Landscapes and the Lifeworld. Indica Books, Varanasi.
28. Soja, E. (1989): Post-modern Geographies. Verso Press, London. Reprinted 1997: Rawat Publications, Jaipur and New Delhi.
29. Taylor, G. (ed.) (1953): Geography in the Twentieth Century.Methuen and Company Ltd. and Company, London.
30. Tuan, Yi-Fu (1977): Space and Place. The Perspective of Experience. Edward Arnold, London.

GMC102. Theory (core), Paper: 2.
Physical Landscape and Hydrology

UNIT I

Bases of Physical Landscape. Concept and types of physical landscape; Significance of geomorphic processes including plate tectonics in landforms development; Geological structure and climatic factors in the development of landforms.

UNIT II

Landforms Development. Interruption in the evolution of landforms: tectonic, climatic, and base-level changes; Development of landforms in various areas: humid, coastal, karsts, and peri-glacial; River terraces: concept and types; Regional geomorphology: Indo-Gangetic plain, and Rajmahal Hills.

UNIT III

Bases of Hydrology. Meaning, scope and development of Hydrology; Hydrological cycle; Man's influence on the hydrological cycle; Precipitation types, characteristics and measurements; Evaporation: factors affecting evaporation from free water surface and soil; Evapotranspiration: estimation and its control.

UNIT IV

Water and Its Disposition. Soil moisture and its zones; Infiltration; Groundwater: occurrence, storage, recharge and discharge; Runoff: its sources and components, factors affecting runoff; River regimes; Hydrograph: components and separation.

Books Recommended

1. Bernhard, H. and James, M. A. (1944): Climatology. McGraw Hill Company, New York.
2. Chorley, R. J. (1995): Atmosphere, Weather and Climate. Methuen and Company Ltd. and Company Ltd., London.
3. Chow, V. T. (ed.) (1954): Handbook of Applied Hydrology: A Compendium of Water Resources Technology. McGraw Hill, New York.
4. Critchfield, H. J. (2003): General Climatology. Prentice-Hall of India, New Delhi.
5. Rai, V.K. (1993): Water Resource Planning and Development, Deep and Deep Publication, New Delhi
6. Bilas, R. (1988): Rural Water Resource Utilization and Planning. Concept Publishing

Company, New Delhi.
7. Reddy, J. P. (1988): A Textbook of Hydrology. Laxmi Publication., New Delhi. 4th edition.
8. Singh, M. B. (1999): Climatology and Hydrology. Tara Book Agency, Varanasi. (In Hindi).
9. Singh, M. B. (2002): Physical Geography. Tara Book Agency, Varanasi. (In Hindi).
10. Singh, S. (1998): Geomorphology. Prayag Pustak Bhavan, Allahabad.
11. Sparks, B.W. (1986): Geomorphology. Longman, London.
12. Thornbury, W.D. (2005): Principles of Geomorphology. John Wiley and Sons, New York.
13. Trewartha, G. T. (1980): An Introduction to Climatology. McGraw Hill Student edition, New York.
14. Ward, R.C. and Robinson, M. (2000): Principles of Hydrology. McGraw Hill, New York.
15. Weisberg, J. S. (1974): Meteorology. Houghton Miffin Company, Boston.
16. Wooldridge, S.W. and Morgan, R.S. (1959): The Physical Basis of Geography- An Outline of Geomorphology. Longmans Green, London.

GMC103. Theory (core) Paper: 3
Advanced Geography of India

UNIT I

Introduction. Making of India through geological times, structure and relief; Drainage systems and watersheds; Physiographic divisions; Climate characteristics: mechanism of the Indian Monsoon; Forests: types, distribution and utilisation.

UNIT II

Population Characteristics. Population growth: trends and pattern; Population: distribution and density; Ageing of population; Sex and literacy differentials; Ethnic groups; Trends of urbanisation; National population policy - 2000.

UNIT III

Agricultural Scene. Agricultural characteristics and trends; Land holdings, land tenure, land consolidation and land reforms; Infrastructure: irrigation, power, fertiliser, HYV seeds and farm technology; Green, white, blue and yellow revolutions.

UNIT IV

Industrial Resource Base. Regional distribution and development potentials of mineral and power resources; New industrial policy: Globalisation and liberalisation; Industrial complexes and industrial regions; Transport development: rail and road; Geographical regions; Detailed study of the Middle Ganga plain and Karnataka plateau region.

Books Recommended.

1. Chapman, G. and Baker, K.M. (eds.) (1992): The Changing Geography of Asia. Routledge, London.
2. Farmer, B.H. (1983): Introduction to South Asia. Methuen and Company Ltd. and Company Ltd., London.
3. Ganguly, S. and Neil, DeVotta (eds.) (2003): Understanding Contemporary India. Lynne Reinner Publishers., Boulder and London.
4. Gole, P. N. (2001): Nature Conservation and Sustainable Development in India. Rawat Publications, Jaipur and New Delhi.
5. Johnson, B. L. C. (ed.) (2001): Geographical Dictionary of India. Vision Books, New Delhi.
6. Johnson, B.L.C. (1983): Development in South Asia. Penguin Books, Harmonsworth.
7. Khullar, D. R. (2006): India. A Comprehensive Geography. Kalyani Publishers., New Delhi.

8. Krishnan, M. S. (1968): Geology of India and Burma. 4th edition. Higgin Bothams Private Ltd., Madras.
9. Nag, P. and Gupta, S. S. (1992): Geography of India. Concept Publishing. Company, New Delhi.
10. Sharma, T. C. (2003): India: Economic and Commercial Geography. Vikas Publication., New Delhi.
11. Singh, J. (2003): India: A Comprehensive and Systematic Geography. Gyanodaya Prakashan, Gorakhpur.
12. Singh, R. L. (ed.) (1971): India. A Regional Geography. National Geographical Society of India, Varanasi.
13. Spate, O.H.K., Learmonth, A.T.A. and Farmer, B. H. (1979): India and Pakistan. Methuen and Company Ltd. and Company Ltd., London.
14. Subbarao, B. (1959): The Personality of India. University of Baroda Press, Baroda.
15. Sukhwal, B.L. (1987): India. Economic Resource Base and Contemporary Political Patterns. Sterling Publication, New Delhi.
16. Tirtha, R. (2002): Geography of India. Rawat Publications., Jaipur and New Delhi.
17. Tiwari, R. C. (2007): Geography of India, Prayag Pustak Bhawan, Allahabad
18. Wadia, D. N. (1959): Geology of India. MacMillan and Company, London and Madras. Student edition.

GMP 104. Practical (core), Paper: 1.
Physical Diagrams, Hydrology and Map Projections

1. Physical Diagrams and Hydrology. Advanced exercises on geological maps: folded and faulted structures, unconformable rock series; Hypsographic and clinographic curves; Drainage basin analysis; Drawing of climatological water balance graph and determination of the components; Calculation of climatic indices: rainfall-runoff relationship; Hydro-graphs: components and separation; Unit hydrograph.

2. Map Projections. Determination of azimuth, retro-azimuth and great circle distances on the earth: Construction of comparative scales for graticules on Mercator's and Gall's projections; Determination of percentage of error in scale and area on selected projections.

GMP 105. Practical (core), Paper: 2.
Spatial Analysis: Locational and Network

1. Locational Analysis. Absolute and relative location: spacing, indices of randomness, deviation and nature of dispersion; Nodes-population clusters: the size continuum, size and shape; Hierarchies: functional hierarchy of settlements and ordering; Interaction: movement and distance models; Service area and territory – serial polygons, interactions zones; Case of agricultural and industrial location.

2. Network Analysis. Topologic structures: branching, circuit and barrier networks; Geometric structures: Networks shape and density, pattern and order; Flow and network efficiency; Location of network routes and boundaries; Pattern of spatial evolution and network transformation.

GMM 501. Minor Elective, Paper: 1.
Remote Sensing Basics

UNIT I

Fundamentals. Remote sensing: definition and scope; Electro-magnetic radiation: characteristics, interaction with matter, Remote sensing regions and bands; Types of remote sensing.

UNIT II

Aerial Photographs. Aerial photos: types, scale, resolution; Geometric properties of single aerial photos; Stereoscopy; Interior and exterior elements of orientation; Stereoscopic parallax; Relief displacement.

UNIT III

Satellite Imagery. General orbital characteristics of remote sensing satellites; General characteristics of remote sensing sensors; Characteristics of MSS, HRV, LISS; Characteristics of raw remote sensing data.

UNIT IV

Interpretation and Application. Elements of image interpretation; Image processing techniques: Visual and digital; Remote sensing data: pre-processing operations, enhancements and classifications; Remote sensing in resource mapping and environmental monitoring.

Books Recommended

1. Campbell, J. B. (2002): Introduction to Remote Sensing. 5th edition. Taylor and Francis, London.
2. Cracknell, A. and Hayes, L. (1990): Remote Sensing Year Book, Taylor and Francis, London.
3. Curran, P.J. (1985): Principles of Remote Sensing, Longman, London.
4. Deekshatulu, B.L. and Rajan, Y.S. (ed.) (1984): Remote Sensing. Indian Academy of Science, Bangalore.
5. Floyd, F. and Sabins, Jr. (1986): Remote Sensing: Principles and Interpretation, W.H. Freeman, New York.
6. Guham, P. K. (2003): Remote Sensing for Beginners. Affiliated East-West Press Private Ltd., New Delhi.
7. Hallert, B. (1960): Photogrammetry, McGraw Hill Book Company Inc., New York.
8. Harry, C.A. (ed.) (1978): Digital Image Processing, IEEE Computer Society, California
9. Hord, R.M. (1982): Digital Image Processing of Remotely Sensed Data, Academic Press, New York.
10. Leuder, D.R. (1959): Aerial Photographic Interpretation: Principles and Application. McGraw Hill, New York.
11. Lillesand, T.M. and Kiefer, R.W. (2000): Remote Sensing and Image Interpretation. 4th edition. John Wiley and Sons, New York.
12. Nag, P. (ed.) 1992: Thematic Cartography and Remote Sensing, Concept Publishing. Company, New Delhi.
13. Reeves, R.G. (ed.) (1983): Manual of Remote Sensing, Vols. 1 and 2, American Society of Photogrammetry and Remote Sensing, Falls Church, Virginia.
14. Siegel, B.S. and Gillespie, R. (1985): Remote Sensing in Geology, John Wiley and Sons, New York.
15. Silver, M. and Balmori, D. (eds.) (2003): Mapping in an Age of Digital Media. Wiley-Academy, New York and Chichester.
16. Spurr, R. (1960): Photogrammetry and Photo Interpretation, The Roland Press Company, London.
17. Survey of India, (1973): Photogrammetry, Survey of India, Dehradun.

18. Swain, P.H. and Davis, S.M. (ed.), (1978): Remote Sensing: The Quantitative Approach. McGraw Hill, New York.

GMS 601. Seminar (Core): 1. Assignment Based Seminar

GMC 106. Theory (core), Paper: 4.
Advanced Geomorphology

UNIT I

Concepts. Recent observations on some fundamental concepts of geomorphology; Concept of time: cyclic, graded and steady state; Concept of morphogenetic region; Concept of dynamic equilibrium; Recent trends in geomorphology.

UNIT II

Drainage Basin and Related Aspects. Drainage basin as a geomorphic unit: morphometric laws; Denudation and morpho-chronology and dating of landscapes; Soil erosion and its measurement.

UNIT III

Theories and Techniques. Theories of hill-slope evolution; Erosion surfaces; Geomorphic mapping techniques; Systems in geomorphology; Models in geomorphology.

UNIT IV

Application in Various Fields. Geomorphic hazards and mitigation measures; Geomorphology and economic deposits; Geomorphology in engineering construction; Geomorphology in groundwater studies; Soils and geomorphology.

Books Recommended

1. Ahmed, E. (1985): Geomorphology. Kalyani Publishers, New Delhi.
2. Bloom, A. L. (1998/ 2001): Geomorphology. 3rd edition. Prentice Hall of India, New Delhi.
3. Chorley, R.J., Schumm, S. A. and Sugden, D. E. (1984): Geomorphology. Methuen and Company Ltd., London.
4. Dayal, P. (1994): A Text Book of Geomorphology. Kalyani Publishers, New Delhi.
5. Fairbridge, R.W. (ed.) (1968): Encyclopaedia of Geomorphology, Reinhold Book Corporation., New York
6. Gregory, K.J. and Walling, D.E. (1973): Drainage Basin Form and Process. Edward Arnold, London.
7. Jog, S. R. (ed.) (1995): Indian Geomorphology (2 vols.). Rawat Publications, Jaipur
8. Kale, V. and Gupta, A. (2001): Introduction to Geomorphology. Orient Longman, Hyderabad.
9. King, C.A.M. (1966): Techniques in Geomorphology. Edward Arnold, London.
10. Pethick, J. (1984): An Introduction to Coastal Geomorphology. Arnold, London. Indian reprint 2000.
11. Sharma, P. R. (ed.), (1993): Applied Geomorphology in Tropics. Rishi Publications, Varanasi.
12. Singh, S. (2004): Geomorphology. Prayag Pustak Bhawan, Allahabad.
13. Sparks, B.W. (1986): Geomorphology. Longmans, London.
14. Thornbury, W.D. (2005): Principles of Geomorphology. John Wiley and Sons, New York.
15. Wooldridge, S.W. and Morgan, R.S. (1959): The Physical Basis of Geography- An Outline of Geomorphology. Longman, London.

GMC 107. Theory (core) Paper: 5.
Geography of Resources

UNIT I

Introduction and Bases. Concept and scope of Resource Geography; Resource: concept and types; World resources: distribution and pattern; Land, water, mineral and power resources; Non-conventional sources of energy; Human resources; Resource base and its dynamism as related to stages of cultural, technological and economic development.

UNIT II

Resource Use. The limits to growth; Resource scarcity hypothesis; World energy crisis; Resource conservation and management; Watershed management; Sustainable development; Resources, development and international politics.

UNIT III

Theories of Resource Use. Theories of agricultural location; Theories of industrial location: Weber, Hoover, and Losch; Trade blocs.

UNIT IV

Regional Perspectives. Resource regionalisation; World economic development; Concept of developed and developing nations; Concepts of North-South and First, Second, Third and Fourth Worlds.

Books Recommended

1. Burton, I. and Kates, R.W. (1978): Readings in Resource Management and Conservation. McGraw Hills, New York
2. Clark, G. L., Feldman, M.P. and Gertler, M.S. (eds.) (2000): The Oxford Handbook of Economic Geography. Oxford University Press, Oxford and New York.
3. Ehrlich, P.R., Ehrlich, R.H. and Holdren, J.P. (1998): Ecoscience: Population, Resources and Development. 2nd edition. Freeman and Company, San Francisco.
4. Sheppard, E. and Treror, I. B. (ed.) (2003): A Companion to Economic Geography, Blackwell Publication, U.K. and USA.
5. McCarty, H.M. and James, B.L. (1976): A Preface to Economic Geography. Prentice Hall, New Jersey.
6. Mitra, A. (2000): Resource Studies; Shridhar Publishers., Kolkata.
7. Ramesh, A. (ed.) (1984): Resource Geography. Heritage Publishers, New Delhi.
8. Singh, J. (2000): *Sansadhan Bhoogol,* Gyanodaya Prakashan, Gorakhpur
9. Singh, K.N. and Singh, J. (2003): *Arthik Bhoogol Ke Mool Tatva,* Gyanodaya Prakashan, Gorakhpur.
10. Todaro, M.P. and Smith, S.C. (2004): Economic Development, Pearson Education, (Singapore) Private Ltd. Singapore

GMP 108. Practical (core), Paper: 3.
Statistical Methods and Data Processing

1. Statistical Methods. The normal frequency distribution curve and its characteristics; Curve fitting; Sampling procedures: random, stratified random, systematic and cluster; Test of significance: Chi-square test, Student's t-test, F-test, Analysis of variance; Analysis of time series.

2. Data Processing. Collection of data: methods, sources and types; Classification and tabulation of data; Data processing devices; Characteristics and component of a computer system; Computer languages; Retrieving and processing of data.

GMM 502. Elective (Minor), Theory Paper: 2.
Population and Development

UNIT I

Conceptual Frame. Population as resource; Population and development: a debate; Population and ecosystem; Demographic transition.

UNIT II

Historical Background and Characteristics. History of human population; Relationship between population, food and energy; Debate on The Limits to Growth; Population characteristics: developed and developing countries (case study of India).

UNIT III

Problems and Policies. Optimum population; Family welfare and planning; Population policies in developed and developing countries (case study of India).

UNIT IV

Population and Development Conflict. Concepts of rich and poor worlds and their global perspectives; Neo-Malthusian theory; Future perspectives: Growth scenario and relationship with development.

Books Recommended

1. Champion, T. (ed.) (1993): Population Matters. Paul Chapman, London.
2. Ehrlich, P.R. and Ehrlich, A.H. (1996): Ecoscience: Population, Resources, Environment. 6th edition, W.H. Freeman and Company, San Francisco.
3. Firor, J. and Jacobsen, J. E. (2003): The Crowded Greenhouse: Population, Climatic Change and Creating a Sustainable World. Universities Press (India) Private. Ltd., Hyderabad.
4. Haggett, P. (2001): Geography, A Modern Synthesis. 5th edition, Harper and Row, New York.
5. Hammett, C. (eds.) (1996): Social Geography: A Reader. Arnold, London.
6. Meadow, D.H., Meadows, D.L., Randers, J. and Behrens, W.W. III (1973): The Limits to Growth. I Report of the Club of Rome. The New American Library, New York.
7. Meadows, D.H., Meadows, D.L. and Randers, J. (1992): Beyond the Limits. Confronting Global Collapse, Envisioning a Sustainable Future. (A sequel to The Limits to Growth). Chelsa Green Publishers, Post Mills VT, USA.
8. Mesarovic, M. and Pester, E. (1974): Mankind at the Turning Point. II Report of the Club of Rome. The New American Library, New York.
9. Middleton, N. and O'Keefe, P. (2001): Redefining Sustainable Development. Pluto Press, London.
10. Ross, J. A. (ed.) (1982): International Encyclopaedia of Population. Free Press, New York.

11. Sharma, P. R. (ed.) (1991): Perspectives on the Third World Development. Rishi Publications., Varanasi.
12. Sharma, P. R. (ed.) (1994): Regional Policies and Development in the Third World. Rishi Publications, Varanasi.
13. Simon, J. L. (1977): The Economics of Population Growth. Princeton University. Press, Princeton.
14. Thakur, B. (ed.) (2004): Population, Resources and Development. Vol. II, Perspectives in Resource Management in Developing Countries. Concept Publishing. Company, New Delhi.
15. Tinbergen, J. (1976): RIO. Reshaping the International Order. III Report of the Club of Rome. The New American Library, New York.
16. U.N.C.E.D. (1987): Our Common Future. UNCED The Centre for Our Common Future, Geneva.

GMS 602. Seminar (Core and Major Elective): 2
Assignment Based Seminar

GMC109. Theory (core), Paper: 6.
GIS and Its Application

UNIT I

Evolution of GIS; Definition and scope of GIS; Components of GIS; Issues and trends in GIS

UNIT II

Geographical data products, types and characteristics; Implications of spherical and planar coordinate systems and their transformations in GIS; Georeferencing and implications of earth's shape and datum in GIS.

UNIT III

Issues in digital representation of geographic data; Raster and Vector models for geographic data representation; GIS data standards—concepts and components; Digital Elevation Model (DEM): process, derivatives and applications.

UNIT IV

Remote sensing and GIS integration, GIS project design and planning methodologies; GIS data base management systems; GIS information products; Applications of GIS.

Books Recommended

1. Bonham, Carter, G.F. (1995): Information Systems for Geoscientists – Modelling with GIS. Pergamon, Oxford.
2. Burrough, P.A. and McDonnell, R. (1998): Principles of Geographic Information Systems. Oxford University Press, Oxford.
3. Chang, K.T. (2003): Introduction to Geographic Information Systems. Tata McGraw Hill Publications Company, New Delhi.
4. Chauniyal, D. D. (2004): Remote Sensing and Geographic Information Systems. (in Hindi). Sharda Pustak Bhawan, Allahabad.
5. Demers, M. N. (2000): Fundamentals of Geographic Information Systems. John Wiley and Sons, Singapore.
6. ESRI (1993): Understanding GIS. Redlands, USA
7. Fraser Taylor, D.R. (1991): Geographic Information Systems. Pergamon Press, Oxford.

8. George, J. (2003): Fundamentals of Remote Sensing. Universities Press Private Ltd, Hyderabad.
9. Girard, M. C. and Girard, C. M. (2003): Processing of Remote Sensing Data. Oxford and IBH, New Delhi.
10. Glen, E. M. and Harold, C. S. (1993): GIS Data Conversion Handbook. Fort Collins, Colorado, GIS Word Inc.
11. Goodchild, M.F., Park, B. O. and Steyaert, L. T. (eds.) (1993): Environmental Modelling with GIS. Oxford University Press, Oxford.
12. Guptill, S.C., and Morrison, J.L. (1995): Elements of Spatial Data Quality. Elsevier/ Pergamon, Oxford.
13. Heywood, I. (2003): An Introduction to Geographical Information Systems. 2nd edition, Pearson Publishing Company, Singapore.
14. Korte, G. M. (2002): The GIS Book. On Word Press: Thomson Learning, New York and Singapore.
15. Lo, C.P. and Yeung, A. K. W. (2002): Concepts and Techniques of Geographic Information Systems. Prentice Hall of India, New Delhi.
16. Longley, P. and Batty, M. (eds.) (1996): Spatial Analysis: Modelling in a GIS Environment. GeoInformation International, Cambridge.
17. Longley, P., Goodchild, M.F., Maguire, D. and Rhind, D. (1999): Geographic Information Systems. Principles, Techniques, Management, Applications. John Wiley and Sons, New York.
18. Maguirre, D. J., Michael, F. G. and David, W. R. (1999): Geographical Information Systems: Principles and Application. Geo Information International, Vol.2, Longman Publication., New York.
19. Martin, D. (1996): Geographic Information Systems: Socioeconomic Implications. Routledge, London.
20. Michael, F. G. and Karan, K. K. (ed.) (1990): Introduction to GIS. NCGIA, Santa Barbara, California.
21. Ralston, B. A. (2002): Developing GIS Solutions with Map Objects and Visual Basic. On Word Press: Thompson Learning, New York and Singapore.
22. Reddy, M. A. (2001): Textbook of Remote Sensing and Geographic Information Systems. B. S. Publications., Hyderabad.
23. Ripple, W. J. (ed.) (1989): Fundamentals of Geographic Information Systems: A Compendium. ASPRS/ ACSM, Falls Church.
24. Siddiqui, M.A. (2005): Introduction to Geographical Information Systems, Sharda Pustak Bhawan, Allahabad.
25. Star, J. and Estes, J. (1990): Geographic Information Systems – An Introduction. Prentice-Hall, Englewood Cliffs, New Jersey.
26. Worboys, M. F. (1995): GIS: A Computing Perspective. Taylor and Francis, London.

GMC110. Theory (core), Paper: 7.
Environmental Studies

UNIT I

Bases. Meaning and scope of environmental geography; Approaches to study of environment; Types of environment, Environment and society, Environment and development, Environmental perception and cognitive maps.

UNIT II

Biogeography and Ecosystem. Definition, scope and significance of biogeography; Basic ecological principles; Geo-biochemical cycles: carbon, nitrogen, oxygen and phosphorus cycles; Biome and biomass; World distribution of plants and animals; Biodiversity: depletion and conservation.

UNIT III

Hazards and Changes. Environmental hazards; Natural hazards: landslides, soil erosion, droughts and floods, earthquakes; Man-made hazards: technological hazards, global climatic changes, global warming, green house effects, ozone depletion, sedimentation in rivers and reservoirs.

UNIT IV

Pollution and Management. Environmental pollution: pollutants, sources and types of pollution; Water, soil, air, and noise pollution; Solid waste disposal; Environmental pollution and health; Environmental education; Environmental impact analysis; Environmental monitoring and standards; Environmental policy and legislation; Environmental management.

Books Recommended

1. Anjuneyulu, Y. (2002): Environmental Impact Assessment Methodologies. B. S. Publications, Hyderabad.
2. Anjuneyulu, Y. (2004): Introduction to Environmental Science. B. S. Publications, Hyderabad.
3. Athavale, R. N. (2003): Water Harvesting and Sustainable Supply in India. Rawat Publications., Jaipur.
4. Bilas, R. (1988): Rural Water Resource Utilization and Planning. Concept Publishing Company, New Delhi.
5. Blaikie, P., Cannon, T. and Davis, I. (eds.) (2004): At Risk: Natural Hazards, Peoples Vulnerability and Disasters. Routledge, London.
6. Clarke, J. I., Curson, P., Kayastha, S. L. and Nag, P. (eds.) (1991): Population and Disaster. Basil Blackwell, USA.
7. Gautam, A. (2007): Environmental Geography, Sharda Pustak Bhawan, Allahabad.
8. Huggett, R. J. (1998): Fundamental of Biogeography. Routledge, London.
9. Kayastha, S.L. and Kumra, V.K. (1986): Environmental Studies. Tara Book Agency, Varanasi.
10. Khoshoo, T. N. (1981): Environmental Concerns and Strategies. Ashish Publishing House, New Delhi.
11. Kumra, V.K. (1982): Kanpur City. A Study in Environmental Pollution. Tara Book Agency, Varanasi.
12. Mathur, H. S. (2003): Essentials of Biogeography. Pointer Publication, Jaipur.
13. Nag, P., Kumra, V.K. and Singh, J. (1990): Geography and Environmental Issues at Local, Regional and National Levels. (in 3 vols.), Concept Publishing Company, New Delhi.
14. Odum, E.P. (1975): Ecology. Rowman and Littlefield, Lanham USA.
15. Rajagopalan, R. (2005): Environmental Studies: From Crisis to Cure, Oxford University Press, New Delhi.
16. Reddy, M. A. (2004): Geoinformatics for Environmental Management. B. S. Publishers., Hyderabad.
17. Saxena, K.K. (2004): Environmental Studies. University Book House Private Ltd., Jaipur
18. Saxena, H. M. (1999): Environmental Geography. Rawat Publications., Jaipur and New Delhi.
19. Saxena, H. M. (2000): Environmental Management. Rawat Publications., Jaipur and New Delhi.
20. Singh, A.K., Kumra, V.K. and Singh, J. (1986): Forest Resource, Economy and Environment. Concept Publishing. Company, New Delhi.
21. Singh, D.N., Singh, J. and Raju, K.N.P. (eds.) (2003): Water Crisis and Sustainable Management, Tara Book Agency, Varanasi
22. Singh, J. (2001): *Paryavaran Evam Samvikas*. Gyanodaya Prakashan, Gorakhpur.
23. Singh, O., Nag, P., Kumra, V.K. and Singh, J. (eds.) (1993): Frontier in Environmental Geography. Concept Publishing Company, New Delhi.

24. Singh, O., Kumra, V.K. and Singh, J. (1988): India's Urban Environment. Pollution, Perception and Management. Tara Book Agency, Varanasi.
25. Singh, R. B. (ed.) (1990): Environmental Geography. Heritage Publication, New Delhi.
26. Singh, R. B. (ed.) (1995): Studies in Environment and Development. Rakesh Prakashan, Varanasi.
27. Singh, Rana P.B. (ed.) (1993): Environmental Ethics: Discourses and Cultural Traditions. National Geographical Society of India, BHU, Varanasi.
28. Singh, S. (2006): Environmental Geography. Prayag Pustak Bhawan, Allahabad.
29. Singh, S. (2007): *Paryavaran Bhugol.* Prayag Pustak Bhawan, Allahabad.
30. Singh, S. N. (1993): Elements of Environmental Geography and Ecology (in Hindi), Tara Book Agency, Varanasi
31. Wrigley, N. (1985): Categorical Data Analysis for Geographers and Environmental Scientists. Longman, London.

GMP 111. Practical (core), Paper: 4.
Remote Sensing and GIS; Soil, Water and Air Analysis

Stereoscopic test; Interpretation of stereograms and stereopairs; Mapping for land use/ land cover; Determination of photoscale; Border information on Landsat/ IRS Images; Visual interpretation of satellite images (Landsat/ IRS); Scanning, digitisation and editing; Base map preparation.
Soil analysis: texture and structure; Water analysis: physical and chemical characteristics; Air analysis: estimation of SPM.

GMF 701: Field Training
Field Study and Geographical Excursion

GMS 603: Seminar (Core Major Elective): 3
Assignment Based Seminar

GMM 503: Elective (Minor) Theory Paper: 3
Resources and Environmental Management

UNIT I

Conceptual Framework. Concept and classification of resources; Resource appraisal and environment; Resource scarcity hypothesis; Resource conservation and management.

UNIT II

Resource Base. Environmental appraisal of land, forests and water resources; World energy crisis; Nuclear and non-conventional / alternate sources of energy.

UNIT III

Bases and Environmental Issues. Environment: components and types; Emerging environmental issues; Biodiversity: use, depletion and conservation; Environment and sustainable development; Environmental degradation.

UNIT IV

Environmental Pollution, Hazards and Management. Environmental pollution: types and effects; Environmental hazards: Natural and man induced, Disaster management, Environmental impact assessment, environmental perception and education; Environmental monitoring and environmental management

Books Recommended

1. Anjuneyulu, Y. (2002): Environmental Impact Assessment Methodologies. B. S. Publications, Hyderabad.
2. Anjuneyulu, Y. (2004): Introduction to Environmental Science. B. S. Publications, Hyderabad.
3. Blaikie, P., Cannon, T. and Davis, I. (eds.) (2004): At Risk: Natural Hazards, Peoples Vulnerability and Disasters. Routledge, London.
4. Clarke, J. I., Curson, P., Kayastha, S. L. and Nag, P. (eds.) (1991): Population and Disaster. Basil Blackwell, Oxford.
5. Gautam, A. (2005): Resource and Environment (in Hindi), Sharda Pushtak Bhawan, Allahabad.
6. Huggett, R. J. (1998): Fundamental of Biogeography. Routledge, London.
7. Kayastha, S.L. and Kumra, V.K. (1986): Environmental Studies. Tara Book Agency, Varanasi.
8. Khoshoo, T.N. (1981): Environmental Concerns and Strategies. Ashish Publishing House, New Delhi
9. Mathur, H. S. (2003): Essentials of Biogeography. Pointer Publishers, Jaipur.
10. Nag, P., Kumra, V.K. and Singh, J. (1990): Geography and Environmental Issues at National, Regional and Local Levels (in 3 Volumes), Concept Publishing. Company, New Delhi.
11. Odum, E.P. (1975): Ecology. Rowman and Littlefield, Lanham, USA.
12. Reddy, M. A. (2004): Geoinformatics for Environmental Management. B. S. Publications, Hyderbad.
13. Saxena, H. M. (1999): Environmental Geography. Rawat Publications., Jaipur and New Delhi.
14. Saxena, H. M. (2000): Environmental Management. Rawat Publications, Jaipur and New Delhi.
15. Singh, A.K., Kumra, V.K. and Singh, J. (1986): Forest Resource, Economy and Environment. Concept Publishing Company. New Delhi
16. Singh, J. (2001): *Paryavaran Evam Samvikas*. Gyanodaya Prakashan., Gorakhpur.
17. Singh, M. B., Kumra, V.K., Singh, Rana P.B., Singh, J., Bilas, R. and Singh, B.N. (eds.) (2005): Sustainable Management of Natural Resources, Tara Book Agency, Varanasi.
18. Singh, O., Nag, P., Kumra, V.K. and Singh, J. (eds.) (1993): Frontier in Environmental Geography. Concept Publishing Company, New Delhi.
19. Singh, O., Kumra, V.K. and Singh, J. (1988): India's Urban Environment. Pollution, Perception and Management. Tara Book Agency, Varanasi.
20. Singh, R. B. (ed.) (1990): Environmental Geography. Heritage Publication, New Delhi.
21. Singh, S. (2006): Environmental Geography, Prayag Pustak Bhawan, Allahabad.
22. Singh, S. (2007): *Paryavaran Bhugol*,. Prayag Pustak Bhawan, Allahabad.
23. Singh, S. N. (1993): *Vatavaran Bhugol*. Tara Book Agency. Varanasi
24. Valdiya, K. S. (1987): Environmental Geology: Indian Context. Tata McGraw Hill Publishing Company. Ltd., New Delhi

GMC-112. Theory (core), Paper: 8.
Interdisciplinary Research Methods and Techniques

UNIT I

Framework of Research. Concept and significance of research in geography; Philosophy and methods: empiricism, positivism, behaviourism.

UNIT II

Planning Research and Data Generation. Primary and secondary data; Data collection and arrangement; Research design; Participatory research; Framing pilot and research project; Making survey-questionnaire

UNIT III

Theories and Techniques. Model making; Application of system theory; Application and relevance of statistical and cartographic techniques; Application of computer and GIS.

UNIT IV

Analysis, Writing and Dissemination. Production and arrangement of data; Analysis of data and maps; Quantitative and qualitative interpretations; Writing manuals (arranging themes, maintaining coherence, cross-comparison, concluding, referencing, noting); Proof marks and marked proof; Writing a research paper/ report.

Books Recommended

1. Ahuja, R. (2001): Research Methods, Rawat Publications, Jaipur and New Delhi.
2. Bhattacharyya, D. K. (2005): Research Methodology, Excel Books, New Delhi
3. Blackburn, J. and Holland, J. (eds.) (1998): Who Changes? Institutionalising Participation in Development. IT Publications, London.
4. Blaxter, L., Hughes, C. and Tight, M. (1996): How to Research. Open University Press, Buckingham.
5. Crang, Mike (1999): Cultural Geography. Routledge, London.
6. Daniels, P., Bradshaw, M., et al. (2000): Human Geography: Issues for the 21st Century. Prentice Hall, London, and Pearson Publishers., Singapore. Indian reprint, 2003.
7. Denzin, N. K. and Lincoln, Y.S., (eds.) (2000): Handbook of Qualitative Research. Thousand Oaks CA. Sage Publications.
8. Dikshit, R. D. (2003): The Art and Science of Geography: Integrated Readings. Prentice-Hall of India, New Delhi.
9. Dorling, D. and Simpson, L. (eds.) (1999): Statistics in Society. Edward Arnold, London.
10. Fisher, P. and Unwin, D., (eds.) (2002): Virtual Reality in Geography. Taylor and Francis, London.
11. Flowerdew, R. and Martin, D. (eds.) (1997): Methods in Human Geography. A Guide for Students Doing a Research Project. Longman, Harlow.
12. Hay, I. (ed.) (2000): Qualitative Research Methods in Human Geography. Oxford University Press, New York.
13. Henn, M., Mark W. and Nick F. (2006): A Short Introduction to Social Research, Vistaar Publications, New Delhi
14. Eyles J. and Smith D. M. (1988): Qualitative Methods in Human Geography, Polity

Press, Dales Brewering Cambridge.
15. Kitchin, R. and Tate, N. (2001): Conducting Research into Human Geography. Theory, Methodology and Practice. Prentice-Hall, London.
16. Kitchin, R. and Fuller, D., (2003): The Academic's Guide to Publishing, Vistaar Publications, New Delhi
17. Limb, M. (2001): Qualitative Methodologies for Geographers. Issue and Debates. Edward Arnold, London.
18. Lofland, J. and Lofland, L.H. (1995): Analysing Social Setting. A Guide to Qualitative Observation and Analysis. Wadsworth, Belmont, CA.
19. Longley, P., Goodchild, M.F., Maguire, D. and Rhind, D. (1999): Geographic Information Systems. Principles, Techniques, Management, Applications. John Wiley and Sons, New York.
20. Maso, I., Atkinson, P.A. Delamont, S. and Verhoeven, J.C. (eds.) (1995): Openness in Research. The Tension between Self and Other. Van Gorcum, Assen, Netherlands.
21. Mikkelsen, B. (2005): Methods for Development Work and Research: A New Guide for Practitioners. Sage Publications, London.
22. Mukherjee, N. (1993): Participatory Rural Appraisal: Methodology and Application. Concept Publishing Company, New Delhi.
23. Mukherjee, N. (2002): Participatory Learning and Action: with 100 Field Methods. Concept Publishing Company, New Delhi.
24. O' Leary, Z. (2005): The Essential Guide in Doing Research, Vistaar Publications, New Delhi
25. Pacione, M. (ed.) (1999): Applied Geography: Principle and Practice. Routledge, London.
26. Parsons, T. and Knight, P. G. (1995): How to Do Your Dissertation in Geography and Related Disciplines. Chapman and Hall, London.
27. Patrick M. and Chapman S. (1990): Research Methods(Third Edition), Routledge, London
28. Peet, R. and Thrift, N. (ed.) (1989/ 2002): New Models in Geography (2 vols.). Rawat Publishers., Jaipur and New Delhi.
29. Rachel, P. et al. (2001): Introducing Social Geographies. Arnold Hodder Group, London and Oxford University Press, Oxford.
30. Robson, C. (1993): Real World Research. A Resource for Social Scientists and Practitioners-Researchers. Blackwell Publishers, Oxford.
31. Rogers, A. and Viles, H. A. (2003): The Student's Companion to Geography. Blackwell Publishers, Oxford. Indian reprint available.
32. Sheskin, Ira, M. (1987): Survey Research for Geographers, Scientific Publishers, Jodhpur.
33. Silverman, D. (1993): Interpreting Qualitative Data. Methods for Analysing Talk, Text and Interaction. Sage Publications, London.
34. Singh, R. L. and Singh, Rana P.B. (1993): Elements of Practical Geography. Kalyani Publishers, Ludhiana and New Delhi. (English and Hindi editions).
35. Singh, Rana P.B. and Singh, R. B. (1981): Changing Frontiers of Indian Village Ecology. National Geographical Society of India, BHU, Varanasi, Publication number 27.
36. Turkle, S. (1996): Life on the Screen: Identity in the Age of Internet. Weidenfeld and Nicolson, London.
37. Wolcott, H. (1995): The Art of Fieldwork. AltaMira Press, Walnut Creek, CA.
38. Wright, D.B. (1997): Understanding Statistics. An Introduction for the Social Sciences. Sage Publications, London.

GMS 604. Seminar (Core and Major Elective): 4.
Assignment Based Seminar

GMF 702. Field Survey: Instrumental and Socio-economic

A. Instrumental. Surveying with the help of Theodolite and levelling by Dumpy Level; Solution of advanced survey problems; Use of GPS and Total Stations.

B. Socio-Economic. Making questionnaire format; Conducting village and household survey and report writing.

GMD 703. Dissertation (Thematic as per Specialization Group)

SPECIALIZATION GROUPS

M.A./M.Sc. GEOGRAPHY. Elective (Major), Group I:
Population and Settlement Geography

GME-201. Elective (Major) Group I: Theory: 1
Population Geography

UNIT I

Bases: Concepts, scope and methodology of population geography; Population dynamics: fertility, mortality and migration; Concepts of ageing: young, stationary and stable population.

UNIT II

Theories: Theories of Population Growth: Malthus, Marx, Optimum and Demographic transition; Migration theories: Ravenstien and Everetts Lee.

UNIT III

Population Resource: Problems of under, over, declining and zero population; Population resource regions of the world; Concepts of human development.

UNIT IV

Case of India: Characteristics of population: age-sex structure, rural-urban, literacy, work force and occupational structure; National population policy.

Books Recommended

1. Bhende, A. A. and Kanetkar T. (2003): Principles of Population Studies, Himalaya Publishing House, Mumbai.
2. Bose, A. (ed.) (2001): Population in India's Development, 1947-2000. Vikas Publications, New Delhi.
3. Champion, T. (ed.) (1993): Population Matters. Paul Chapman, London.
4. Chandna, R. C. (2006): Geography of Population. Kalyani Publishers., New Delhi.
5. Clark, J. I. (1972): Population Geography. Pergamon Press, Oxford.
6. Dube, K.K. and Singh, M.B. (1994): *Jansankhya Bhoogol*, Rawat Publications, Jaipur and New Delhi.
7. Ehrlich, P.R. and Ehrlich, A.H. (1996): Ecoscience: Population, Resources, Environment. 6th ed. W.H. Freeman and Company, San Francisco.
8. Garnier, B.J. (1993): Geography of Population. 3rd edition. Longman, London.
9. Jones, H. R. (2000): Population Geography. 3rd edition. Paul Chapman, London.

10. Pathak, L. P. (ed.) (1998): Population Studies. Rawat Publications., Jaipur and New Delhi.
11. Peters, G. L. and Larkin, R.P. (1983): Population Geography. Problems, Concepts and Prospects. Kendall/Hunt, Dubuque, IA.
12. Poston, D. L. and Michael, M. (2005): Handbook of Population, Springer Heidelberg, Germany.
13. Ross, John A. (ed.) (1982): International Encyclopaedia of Population. Free Press, New York.
14. Singh, K.N. and Singh, D.N. (eds.) (1992): Population Growth, Environment and Development. EDSC, Varanasi.
15. Srinivasan, K, and Vlassoff, M. (2001): Population Development Nexus in India: Challenges for the New Millennium. Tata McGraw Hill, New Delhi.
16. Trewartha, G.T. (1985): A Geography of Population. World Patterns. John Wiley and Sons, New York.
17. Woods, R. (1979): Population Analysis in Geography. Longman, London.
18. Zelinsky, W., Kosinski, L. A. and Prothero M. R. (eds.) (1970): Geography and a Crowding World. Oxford University Press, New York and Oxford.
19. Zelinsky, W. (1966): A Prologue to Population Geography. Prentice Hall, Englewood Cliffs, New Jersey.

GMP 202. Elective (Major, Group I), Practical: 1.
Population Geography

1. Population growth of India and the world using arithmetic and semi-log scales; Population distribution map of India using dot and sphere/circle, cubes, combined; Density map of India by Choropleth; Age-sex structure of rural-urban population of India by Superimposed pyramid; Literacy Level by Compound pyramid; Occupational structure of India by Divided rectangle; Fertility, mortality and natural growth of population by Polygraph.

2. Population potential map by Isopleth; Scatter diagram; Life table calculation; Computation of HDI for India; Migration by Flow diagram; Centrographic analysis of population growth; Measurement of population concentration by cumulative curve..

GME-203. Elective (Major, Group I), Theory: 2.
Geography of Rural Settlements

UNIT I

Bases, Evolution and Models. Nature, scope, definition and significance of Rural Settlement Geography; Human settlement as a system; Concepts and characteristics of rural settlements; Theories and models of settlement diffusion: Eric Bylund (Sweden), Gunnar Olsson (Sweden), David Grossman (Nigeria), John Hudson (USA), Contributions of Banaras School.

UNIT II

Spatiality and Histogenesis. Evolution and growth of rural settlements and their causes: Old and New Worlds; Siting and location of rural settlements; Distribution, spacing, and nature of dispersion; Types and patterns; Morphology of village: examples from Germany, Japan, Israel, African countries; Rural-service centres: nature, hierarchy, service area, and interaction.

UNIT III

Rural Dwellings. Traditional and folk rural house types: origin, evolution and characteristics; Typology based on building materials, plans, uses and architectural style; House types and their characteristics in different geographical environments: Monsoon Asia and Arid zone.

UNIT IV

Indian Village. Evolution and multiplicity; Regional morphological characteristics; Morphological interaction models: religio-ritual, secular-economic, and sacred-economic interlocking system; Transformation and planning of Indian village: models and plans.

Books Recommended

1. Daniel, P. (2002): Geography of Settlement. Rawat Publications., Jaipur and New Delhi.
2. Eidt, R. C., Singh, K. N. and Singh, Rana, P.B. (eds.) (1977): Man, Culture and Settlement. Kalyani Publishers., New Delhi.
3. Ghosh, S. (1999): A Geography of Settlements. Orient Longman, Kolkata.
4. Hudson, F. S. (1976): A Geography of Settlements. MacDonald and Evans, New York.
5. Mitra, A. (1960): Report on House Types and Village Settlement Patterns in India. Publication Division, Govt. of India, New Delhi.
6. Mosley, M.J. (2005): Rural Development: Principles and Practice. Sage Publication, London.
7. Oliver, P. (1987): Dwellings. The House across the World. University of Texas Press, Austin.
8. Rapoport, A. (1969): House, Form and Culture. Prentice-Hall, Inc., Englewood Cliffs, NJ.
9. Rykwert, J. (ed.) (2004): Settlements. University of Pennsylvania Press, University Park, USA.
10. Singh, R.L. (eds.) (1973): Rural Settlements in Monsoon Asia, National Geographical Society of India, Varanasi.
11. Singh, R. L., Singh, K.N. and Singh, Rana P.B. (eds.) (1975): Readings in Rural Settlement Geography, National Geographical Society of India, Varanasi.
12. Singh, R. L. and Singh, Rana P. B. (eds.) (1978): Transformation of Rural Habitat in Indian Perspective, National Geographical Society of India, Varanasi, Pub. 19.
13. Singh, R.L. and Singh, Rana P.B. (eds.) (1979): Place of Small Towns in India. National Geographical Society of India, Varanasi,
14. Singh, R.L., Singh, K.N and Singh Rana P.B. (eds.) (1976): Geographic Dimensions of Rural Settlements. National Geographical Society of India, Varanasi,
15. Singh, Rana P.B. (1977): Clan Settlements in the Saran Plain, National Geographical Society of India, Varanasi,
16. Singh, Rana P.B. and Singh, R.B. (1981): Changing Frontiers of Indian Village Ecology. National Geographical Society of India, Varanasi, Pub. 27.
17. Singh, R.Y. (2005): Geography of Settlements. Rawat Publications, Jaipur and New Delhi.
18. Singh, S.B. (1977): Rural Settlement Geography. U.B.B.P., Publications, Gorakhpur.
19. Tiwari, R. C. (2000): Settlement Geography; in Hindi. Prayag Pustak Bhawan Allahabad.
20. Wanmali, S. (1983): Service Centres in Rural India. B.R. Publications Corporation, New Delhi.
21. Wood, M. (2005): Rural Geography: Processes, Responses and Experiences of Rural Restructuring. Sage Publication, London.

GMP 204. Elective (Major, Group I), Practical: 2.
Geography of Rural Settlements

1. Spatial Systems. Size classification of rural settlements by scatter diagrams; Rural settlement distribution and types in India; Density function and pattern analysis of distribution of settlements: randomness and spacing indices, Testing Christaller's theory; Theoretical models of rural settlements and testing of different hypothesis;

2. Studies from India. Typological classification of rural settlements from maps; Rural service centres: indices, hierarchy, classification and ordering; Mapping the morphology of Indian villages; Planning of Indian villages: models, plans and case studies.

GME 205. Elective (Major, Group I), Theory: 3.
Urban Geography

UNIT I

Bases. Meaning and scope of urban geography; Recent trends in urban geography; Urban population: characteristics, processes and trends of urbanisation; Methodology in urban studies; Origin and evolution of urban settlements; Distribution of urban centres.

UNIT II

Characteristics. Characteristics of cities in different historical periods (both industrial and pre-industrial); Functions and functional classification of towns; Urban transportation; Contributions of Banaras School and others.

UNIT III

Spatiality and Models. Size and spacing of cities: Rank-size rule; Law of the primate city; Urban hierarchies; Central Place Theory (Christaller and Lösch); Urban land use and functional morphology: functional areas and peri-urban areas; Theories of urban structure (Burgess, Hoyt, Harris and Ullman, Mann, White).

UNIT IV

Issues and Planning. Urban problems: environmental, urban poverty, slums, transportation, housing, crime; Planned cities: Chandigarh and Jaipur; National Urban Policy and Urban land use planning, Master Plans: A case study of Varanasi.

Books Recommended

1. Bridge, B. and Watson, S. (eds.) (2000): A Companion to the City. Blackwell, Oxford.
2. Carter, H. (1995): The Study of Urban Geography. 4th ed. Reprinted in 2002 by Rawat Publications, Jaipur and New Delhi.
3. Dubey, K.K. (1976): Use and Misuse of Land in KAVAL Towns. National Geographical Society of India, Varanasi.
4. Dubey, K.K. and Singh, A.K. (1983): Urban Environment in India. Deep and Deep, New Delhi.
5. Dutt, A., Allen, K., Noble, G., Venugopal G. and Subbiah S. (eds.) (2003): Challenges to Asian Urbanisation in the 21st Century. Kluwer Academic Publishers, Dordrecht and London.
6. Hall, P. (1992): Urban and Regional Planning. Routledge, London.
7. Hall, T. (2001): Urban Geography. 2nd edition. Routledge, London.
8. Haughton, G. and Hunter, C. (1994): Sustainable Cities. Jessica Kingsley, London.
9. Jacquemin, A. (1999): Urban Development and New Towns in the Third World – A Lesson from the New Bombay Experience. Ashgate, Aldershot, UK.
10. Johnson, J.H. (1981): Urban Geography, Pergaman Press, Oxford.
11. Mayer, H. and Cohn, C. F. (1959): Readings in Urban Geography, University. of Chicago Press, Chicago.
12. Paddison, R. (ed.) (2001): Handbook of Urban Studies. Sage, London.
13. Pacione, M. (2005): Urban Geography: A Global Perspective, Routledge, London and New York.
14. Ramachandran, R. (1991): Urbanisation and Urban Systems in India. Oxford University Press, Delhi.
15. Rao, B. P. and Sharma, N. (2007): *Nagariya Bhoogol*, Vasundhara Prakashan, Gorakhpur.
16. Singh. H. H. (1972): Kanpur: A Study in Urban Geography, Indrasini Publications, Varanasi
17. Singh, K. and Stainberg, F. (eds.) (1998): Urban India in Crisis. New Age International, New Delhi.
18. Singh, O. P. (1987): *Nagariya Bhoogol*, Tara Book Agency, Varanasi
19. Singh, R.L. (1955): Banaras. A Study in Urban Geography. Nand Kishore and Brothers, Banaras.
20. Singh, R.L. and Singh, Rana P.B., (eds.) (1979): Place of Small Towns in India. National

Geographical Society of India, Varanasi,
21. Singh, Rana P.B. and Rana, P.S. (2002): Banaras Region. Indica Books, Varanasi.
22. Singh, S. B. (ed.) (1996): New Perspectives in Urban Geography. M.D. Publications, New Delhi
23. Singh, T.D. (1985): Spatial Pattern of Population in the Cities of U.P. Tara Book Agency, Varanasi
24. Stanley, B., Jack, W. and Donald, Z. (eds.) (2003): Cities of the World. Rowman and Littlefield, New York and Oxford.

GMP 206. Elective (Major, Group I), Practical: 3.
Urban Geography

1. Global Perspective. Theoretical models of urban growth, infrastructure, community zone based study of maps; Functional interpretation of urban morphology and town plan through the ages; Functional classification of towns based on occupational data, population size and centrality.

2. Indian Perspective. Structural and growth analysis of Indian cities and conurbations; Determination of urban hierarchy in Indian region; Determination of population density gradient in urban areas; Application of rank-size rule in a selected area of India; Urban survey and mapping of functional areas of cities.

MA/ MSc GEOGRAPHY. Elective (Major), Group II:
Applied Geography and Planning

GME 301. Elective (Major, Group II), Theory: 1.
Resource Planning

UNIT I

Basic Framework. Meaning, purpose and scope of resource planning; Methods and techniques of resource appraisal; Concepts and approaches of sustainable development; Human resource development.

UNIT II

Resource Conservation. Principles of resource conservation; Resource management; Conservation and planning of resources: land, water, forest, and minerals (with special reference to India).

UNIT III

Indian Perspective. Resource utilisation and development; Impact of resource utilisation on environment; Environmental planning and policy in India; Resource potentials and resource regions; Agriculture region; Population resource region.

UNIT IV

Case Study of India. Resource planning units and development strategies: Damodar Valley and National Capital Region(NCR).

Books Recommended

1. Adam, M.G.(2000a): Kumasi Natural Resources Management, Final Technical Report, Natural Resources Institute, University of Greenwich-UK
2. Adams, W. M. (1990): Green Development: Environment and Sustainability in the Third World. Routledge and Chapman Hall, London.
3. Alam, S. Manzoor and Kidwai, Atiya Habeeb (eds.) (1987): Regional Imperatives in Utilization and Management of Resources: India and the U.S.S.R. Concept Publishing. Company, New Delhi.

4. Burton, I. and Kates, R.W. (1978): Readings in Resource Management and Conservation. McGraw Hills, New York.
5. Corbridge, S. (ed.) (1995): Development Studies: A Reader. Arnold, London.
6. Ehrlich, P.R., Ehrlich, R.H. and Holdren, J.P. (1998): Ecoscience: Population, Resources and Development. 2nd ed. Freeman and Company, San Francisco.
7. Frayer, D.W. (1965): World Economic Development. McGraw Hill, New York.
8. Freeman, T.W. (1972): Geography and Planning. Freeman and Company, New York.
9. Gupta, P., and Sdasyuk, G. (1968): Economic Regionalization of India: Problems and Prospects. Census of India, New Delhi
10. Holechek, J. L., Cole, R., Fisher, J., and Valdez, R. (2000): Natural Resources: Ecology, Economics and Policy. Prentice-Hall, New Jersey..
11. Mitchell, B. (1979): Geography and Resource Analysis. Longman, London
12. Mitchell, B. (1997): Geography and Environmental Management. Longman, Harlow and London.
13. Mitra, A. (1999): Resource Studies; Shridhar Publications., Calcutta.
14. Prasad, H. et al.(eds.) (2005): Sustainable Management of Water Resources, Tara Book Agency, Varanasi
15. Preston, P. W. (1996): Development Theory: An Introduction. Blackwell Publications, Oxford.
16. Rao, P. K. (2001): Sustainable Development: Economics and Policy. Blackwell Publications., Oxford.
17. Raza, M. (ed.) (1989): Renewable Resources for Regional Development: The Indian and the Soviet Experience. Concept Publishing Company, New Delhi.
18. Rees, J. (1985): Natural Resources: Allocation, Economics and Policy.Methuen and Company Ltd., London.
19. Reid, S. (2000): Global Environmental Outlook. Earthscan, London.
20. Reid, S. (1995): Sustainable Development. Earthscan, London.
21. Simon, D. and Närman, A. (eds.) (1999): Development Theory and Practice. Longman.
22. Simon, D. (ed.) (2005): Fifty Key Thinkers on Development. Routledge, London.
23. Singh, M. B. et. al. (eds.) (2005): Sustainable Management of Natural Resources. Tara Book Agency, Varanasi.
24. Sundaram, K.V. (1983): Geography of Under Development. Concept Publishing Company, New Delhi.
25. Sundaram, K.V., Mani, M. and Jha, M.M. (eds.) (2004): Natural Resource Management and Livelihood Security. Concept Publishing Company, New Delhi.
26. Thakur, B. (ed.) (2003): Perspectives in Resource Management in Developing Countries. Vol. I: Resource Management: Theory and Techniques, Concept Publishing Company, New Delhi.
27. Trivedi, P.R., Singh, U.K., Sudershan, K., Tuteja, T.K. (1994): International Encyclopedia of Ecology and Environment. Vol. 5: National Resource Conservation, Indian Institute of Ecology and Environment, New Delhi.
28. UNDP (2001-04): UNDEP Human Development Report. Oxford University Press.
29. Valdiya, K. S. (1987): Environmental Geology: Indian Context. Tata McGraw Hill Publishing Company. Ltd., New Delhi
30. World Bank (2001-05): World Development Report. Oxford University Press, New York.

GMP 302. Elective (Major, Group II), Practical: 1.
Resource Planning

Population Resource region – a case study; Computation of human development Index: a case study; Demographic transition model: a case study; Agricultural productivity; Agricultural efficiency and Delineation of crop combination regions: National Capital Region: A resource appraisal planning unit; Relationship between energy, human resource and economic development.

GME 303. Elective (Major, Group II), Theory: 2.
Regional Planning

UNIT I

Fundamentals. Concept, nature and scope of Regional Planning; Different approaches to regional planning; Planning regions: concept and types; Planning regions of India; Regional policies in India.

UNIT II

Conceptual Outlook. Regional planning and national development; Economic development and regional development; Regional economic complexes; Inter-regional and intra-regional functional interactions; Regional disparities in India.

UNIT III

Approaches. Approaches to integrated regional planning at different levels: local, regional and national; Multi-level planning in India: State, District and Block level planning; Planning for tribal, agricultural, industrial and urban (metropolitan) regions.

UNIT IV

Development Perspective. Service and market centres planning; Growth centre and regional development with reference to India and France; Decentralised planning: themes and issues; Regional planning: Development strategies in the 21st century.

Books Recommended

1. Chandna, R. C. (2000): Regional Planning: A Comprehensive Text. Kalyani Publishers., New Delhi.
2. Chaudhuri, J. R. (2001): An Introduction to Development and Regional Planning with special reference to India. Orient Longman, Hyderabad.
3. Cowen, M.P. and Shenton, R.W. (1996): Doctrines of Development. Routledge, London.
4. Doyle, T. and McEachern, D. (1998): Environment and Politics. Routledge, London.
5. Friedmann, J. (1992): Empowerment: The Politics of Alternative Development. Blackwell, Cambridge MA and Oxford.
6. Friedmann, J. and Alonso, W. (ed.) (1973): Regional Development and Planning. The MIT Press, Mass.
7. Hettne, B., Inotai, A. and Sunkel, O. (eds.) (1999 – 2000): Studies in the New Regionalism. Vol. I-V. Macmillan Press, London.
8. Isard, W. (1960): Methods of Regional Analysis. MIT Press, Cambridge, MA.
9. Kuklinski, A. R. (1972): Growth Poles and Growth Centres in Regional Planning. Mouton and Co., Paris.
10. Kuklinski, A.R. (ed.) (1975): Regional Development and Planning: International Perspective, Sijthoff-Leydor.
11. Leys, C. (1996): The Rise and Fall of Development Theory. Indian University Press, Bloomington, and James Curry, Oxford.
12. Mahapatra, A.C. and Pathak, C. R. (eds.) (2003): Economic liberalisation and Regional Disparities in India. Special Focus on the North Eastern Region. Star Publishing House, Shillong.
13. Kane, M. and William M.K.T. (2007): Concept Mapping for Planning and Evaluation, Sage Publications, London.
14. Misra, R. P. (ed.) (1992): Regional Planning: Concepts, Techniques, Policies and Case Studies. 2nd edition. Concept Publishing Company., New Delhi.
15. Misra, R.P. and Natraj, V.K. (1978): Regional Planning and National Development. Vikas, New Delhi.

16. Misra, R.P., Sundaram, K. V. and Prakasa Rao, V. L. S. (1976): Regional Development Planning in India. Vikas Publishers, New Delhi.
17. Moseley, M.J. (1974): Growth Centres in Spatial Planning. Pergamon Press, Oxford.
18. Närman, A. and Karunanayake, K. (eds.) (2002): Towards a New Regional and Local Development Research Agenda. Dept. of Geography, Göteborg University (Sweden), series B, No100 and Centre for Development Studies, University of Kelaniya (Sri Lanka), No. 1.
19. Norgaard, R. B. (1994): Development Betrayed. The End of Progress and a Coevolutionary Revisioning of the Future. Routledge, London.
20. Pathak, C. R. (2003): Spatial Structure and Processes of Development in India. Regional Science Association., Kolkata.
21. Sanyal, B. M. (2001): Decentralised Planning: Themes and Issues. Concept Publishing. Company, New Delhi.
22. Sharma, P. V., Rao, V. L., and Pathak, C. R. (eds.) (2000): Sustainable Regional Development (with special reference to Andhra Pradesh). Regional Science. Assocation, Kolkata and School of Economics, Andhra University, Vishakapatnam.
23. Sen, A. (1999): Development as Freedom. Oxford University Press, Oxford.
24. Sen, A. and Dreze, J. (eds.) (1996): Indian Development: Selected Regional Perspectives. Oxford University Press, Oxford.
25. Smith, D. and Närman, A. (eds.) (1999): Development Theory and Practice: Current Perspectives on Development and Development Co-operation. Longman, London.
26. Stöhr, W. B. and Taylor, D.F.R. (eds.) (1981): Development from Above and Below? The Dialectics of Regional Planning in Developing Countries. John Wiley and Sons, Chichester.
27. Sundaram, K. V. (1997): Decentralized Multilevel Planning: Principles and Practice (Asian and African Experiences). Concept Publishing Company, New Delhi.
28. Sundaram, K. V. (2004): The Trodden Path: Essays on Regional and Micro Level Planning. Anaunya Publications., New Delhi.
29. Toye, J. (1987): Dilemmas of Development. Reflections on the Counterrevolution in Development Theory and Policy. Basil Blackwell, Oxford.
30. Verhelst, T. (1990): No Life Without Roots – Culture and Development. Zed Books, London.
31. World Bank (2000): Attacking Poverty. World Development Report 2000-01. The World Bank and Oxford University Press, New York; see website: www.worldbank.org/poverty/wdrpoverty/
32. World Bank (2000): Entering the 21st Century. World Development Report. The World Bank and Oxford University Press, New York and Oxford.
33. Yugandhar, B. N. and Mukherjee, A. (eds.) (1991): Readings in De-centralised Planning (with special reference to District Planning), 2 vols. Concept Publishing. Company, New Delhi.

GMP 304. Elective (Major, Group II), Practical: 2.
Regional Planning

Regional planning of a given area: District planning; Service centre planning: Micro level planning; Central place hierarchy and growth centre in regional development; Delineation of city region/ Umland: a case study; Identification and demarcation of axial growth: a case study.

GME 305. Elective (Major, Group II), Theory: 3
Rural and Urban Planning

(A) Rural Planning

UNIT I

Meaning, concept and scope of rural development and planning; Approaches to rural development; Policies and paradigms of rural development programmes; Basic infrastructures for rural development; People's participation in rural planning and rural industrialisation.

UNIT II

Rural Land use: concepts, principles and classification; Rural land use changes and systems in India; Carrying capacity of land; Agricultural efficiency.

(B) Urban Planning

UNIT III

Meaning, concept and scope of urban planning; Urban planning: methods and techniques; Urban land use: models and planning; Urban renewal and re-development of towns; Urban transportation planning.

UNIT IV

Optimum city-size; New and Satellite towns; City planning in India: principles and approaches; Urban planning: case studies of Chandigarh and Varanasi.

Books Recommended

1. Bhat, L.S. (1976): Micro Level Planning in India, K.B. Pub. New Delhi.
2. Bhat, L.S. (1988): Strategy for Integrated Area Development. Case Study of North Kanara District (Karnataka). Concept Publishing. Company, New Delhi.
3. Chambers, R. (1997): Whose Reality Counts? Putting the First Last. Intermediate Technology Publications, London.
4. Chisholm, M. (1962): Rural Settlement and Land Use. Hutchinson, London.
5. Desai, A. R. (1990): Rural Development, Popular Prakashan, Bombay.
6. Desai, V. and Potter, R. (eds.) (2002): The Arnold Companion of Development Studies. Arnold, London.
7. Found, W.C. (1982): Theoretical Approach to Rural Land Use Pattern.Methuen and Company Ltd., London.
8. Hall, P. (1992): Urban and Regional Planning. Routledge, London.
9. Jr. Chapin S. F., Kaiser, E. J. and Godschalk, D. R. (1995): Rural and Urban Land-use Planning, University of Illinois Press Urbanq and Chicago
10. Krishnamurthy, J. (2000): Rural Development. Problems and Prospects. Rawat Publications, Jaipur.
11. Learmonth, A.T.A. (1962): Sample Villages in Mysore. Liverpool Univ. Press.
12. Lejonhud, K. (2003): Indian Villages in Transformation. A Longitudinal Study of Three Villages in Uttar Pradesh. Karlstad University Studies, Karlstad.
13. Long, C. (2001): Participation of the Poor in Development Initiatives: Taking Their Rightful Place. Earthscan, London.
14. Misra, R. P. and Achyutha, R. N. (1998): Micro-Level Rural Planning: Principles, Methods and Case Studies. Concept Publishing. Company, New Delhi.
15. Misra, R. P. and Misra, K. (eds.) (1998): Million Cities of India, Sustainable Development Foundation, New Delhi.
16. Racine, J. (ed.) (1990): Calcutta 1981: The City, its Crisis, and the Debate on Urban Planning and Development. Concept Publishing Company, New Delhi.
17. Sachdev, V. and Tillotson, G. (2002): Building Jaipur: The Making of an Indian City. Reaktion Books, London.
18. Sharma, P. R. (ed.) (1991): Perspectives on the Third World Development. Rishi Publications, Varanasi.
19. Sharma, P. R. (ed.) (1994): Regional Policies and Development in the Third World. Rishi

Publications, Varanasi.
20. Singh, B. N. (1988): Integrated Rural Area Development and Planning. Anupama Publications., Delhi.
21. Singh, R. L. and Singh, Rana P. B. (eds.) (1980): Rural Habitat Transformation in World Frontiers. National Geographical Society of India, Varanasi, Pub. 30.
22. Singh, R. L. and Singh, Rana P. B. (eds.) (1984): Environmental Appraisal and Rural Habitat Transformation. National Geographical Society of India, Varanasi, Pub. 32.
23. Sundaram, K.V. (1977): Urban and Regional Planning in India. Vikas, New Delhi.
24. UNAPDI (1986): Local Level Planning and Rural Development: Alternative Strategies. (United Nations Asian and Pacific Development Institute, Bangkok). Concept Publishing Company, New Delhi.
25. UNDP (United Nations Development Programme) (2004): Human Development Report 2004. UNDP and Oxford University Press, New York, available at website: www.undp.org/hdro/HDR2004/html
26. Yugandhar, B. N. and Mukherjee, N. (eds.) (1991): Studies in Village India: Issues in Rural Development. Concept Publishing. Company, New Delhi.

GMP 306. Elective (Major, Group II), Practical: 3.
Rural and Urban Planning

1. Rural Planning. Rural land use maps (India and UK); International colour scheme and its applicability in Indian context; Intensive rural land use survey and application of locational theories; Land capability: its determination and mapping; Sample field mapping and planning of land use in given rural areas.

2. Urban Planning. Preparation of urban land use maps from topo-sheets; Diagrammatic representation of internal structure of urban centres based on traditional theories; Examination of Master Plans of towns from different areas; Planning a new town (considering urban land use), neighbourhood and community centre plan; Preparation of redevelopment and development sketch plan.

MA/ MSc GEOGRAPHY. Elective (Major), Group III:
Cartography and Remote Sensing

GME 401. Elective (Major, Group III), Theory: 1.
Advanced Cartography

UNIT I

Measuring the Earth. Properties of sphere; The Earth: its shape and size; Coordinate reference system on the sphere; Celestial coordinates: Equatorial system, Horizon system; Geographical co-ordinates and grid system; UTM grids.

UNIT II

Survey. Curvature of the earth and its effect on survey and levelling; Geographical Positioning System (GPS); Trigonometrical surveying; Calculation of height by Levelling.

UNIT III

Map Projections. Choice and classification of map projections; Derivations of formulae for construction of: Conical equal area with One and Two standard parallels (Lambert's and Alber's); International Map projection.

UNIT IV

Science of Cartography. History and development of Cartography; Science of cartography and communication theory; Sources of cartographic data; Cartographic techniques and methods in preparation of diagrams and maps; Thematic mapping; soil and vegetation maps, Environmental maps and Population maps (rural and urban); Atlas Mapping; Pre- and -post census mapping; Automation and computer cartography.

Books Recommended

1. Bailey, T. and Gatrell, A. C. (1995): Interactive Spatial Data Analysis. Longman , Harlow.
2. Dorling, D. and Fairborn, D. (1997): Mapping. Ways of Representing the World. Longman, Harlow.
3. Fraser Taylor, D.R. (1980): The Computer in Contemporary Cartography. John Wiley and Sons, New York.
4. Fraser Taylor, D.R. (ed.) (1983): Graphic Communication and Design in Contemporary Cartography. John Wiley and Sons, New York.
5. Griffith, D. A. and Amehein (1997): Multivariate Statistical Analysis for Geographers. Prentice Hall, Englewood Cliffs, New Jersey.
6. Griffith, D. A. and Amehein (1997): Statistical Analysis for Geographers. Prentice Hall, Englewood Cliffs, New Jersey.
7. Kanetkar, T.P. and Kulkarni, S.V. (1967): Surveying and Levelling, Part II, A.V.G. Prakashan, Poona.
8. Keates, J.S. (1973): Cartographic Design and Production, Longman Group Ltd.
9. Mailing, D.H. (1973): Co-ordinate Systems and Map Projections. George Philip and Sons Ltd.
10. Monkhouse, F.J. and Wilkinson, H. R. (1962): Maps and Diagrams, Methuen and Company Ltd., London.
11. Nag, P. (ed.) (1984): Census Mapping Survey, Concept Publishing Company, New Delhi.
12. Nair, N. B. (1996): Encyclopaedia of Surveying, Mapping and Remote Sensing. Rawat Publications., Jaipur and New Delhi.
13. Raisz, E. (1962): Principles of Cartography. McGraw Hill Books Company, Inc., New York.
14. Misra, R.P. and Ramesh, A. (1999): Fundamentals of Cartography. Concept Publishing Company, New Delhi.
15. Rhind, B. and Adams, T. (ed.) (1983): Computers in Cartography. British Cartographic Society, London.
16. Rice, Oxley, M.K. and Shearer, W.V. (1929): Astronomy for Surveyors. Methuen and Company Ltd. and Company, London.
17. Robinson, A. H. H., Sale R., Morrison J. and Muehrcke, P. C. (1984): Elements of Cartography. 6th edition John Wiley and Sons, New York.
18. Shaw, G. and Wheeler, D. (1994): Statistical Techniques in Geographical Analysis. Prentice Hall, Englewood Cliffs, New Jersey.
19. Singh, R. L. and Singh, Rana P.B. (1993): Elements of Practical Geography. Kalyani Publishers, Ludhiana and New Delhi. (English and Hindi editions).
20. Strahler, A.N. (1971): The Earth Sciences. Harper and Row Publishers; New York.
21. Thrower, N. (1996): Maps and Civilisation. Cartography, Culture and Society. University of Chicago Press, Chicago.
22. Unwin, D. (1982): Introductory Spatial Analysis. Methuen and Company Ltd., London.
23. Walford, N. (1995): Geographical Data Analysis. John Wiley and Sons, Chichester.

GMP 402. Elective (Major, Group III), Practical: 1.
Advanced Cartography

1. Survey and Map Projections. Calculation of height by levelling and Theodolite; Contour planning; Construction of map projections (mathematical method): Conical equal area with one and two standard parallels (Lambert's and Alber's), International and Gnomonic Equatorial.

2. Cartographic Methods. Enlargement and reduction methods; Designing and preparation of a map on various scales; Representation of statistical data by various cartographic methods; Preparation of one general purpose map and one special purpose map.

GME 403. Elective (Major, Group III), Theory: 2.
Aerial Photo Interpretation

UNIT I

Relief displacement; Stereoscopic parallax; Parallax equation and its approximation; Digital photogrammetry and orthophotos.

UNIT II

Qualitative information, philosophy and sequence in air photo interpretation; Elements of air photo pattern: landforms, drainage, erosion details, gray-tones, vegetation; Elements of image interpretation.

UNIT III

Interpretation keys and their types; Aerial mosaics; Multi-spectral aerial photographs; Ground control for mapping from aerial photos; Rectification methods in aerial photos.

UNIT IV

Aerial photo interpretation in general resource evaluation; Geomorphic studies and mapping. Land use/Land cover mapping; Hydro-geomorphic mapping; Environmental monitoring and mapping.

Books Recommended

1. Cracknell, A. and Ladson, H. (1990): Remote Sensing Year Book. Taylor and Francis, London.
2. Curran, P.J. (1988): Principles of Remote Sensing. ELBS Longman, Essex, U.K.
3. Deekshatulu, B.L. and Rajan, Y.S. (ed.) (1984): Remote Sensing. Indian Academy of Science, Bangalore.
4. Floyd, F. S. Jr. (1997): Remote Sensing: Principles and Interpretation. W.H. Freeman, New York.
5. Hallert, B. (1960): Photogrammetry. McGraw Hill Book Company. Inc. New York
6. Leuder, D.R. (1959): Aerial Photographic Interpretation: Principles and Application, McGraw Hill, New York.
7. Lillesand, T.M. and Kiefer, R.W. (2000): Remote Sensing and Image Interpretation. 4th ed. John Wiley and Sons, New York.
8. Rampal, K.K. (1999): Handbook of Aerial Photography and Interpretation. Concept Publishing Company, New Delhi.
9. Reeves, R.G. (ed.) (1983): Manual of Remote Sensing. Vols. 1 and 2, American Society of Photogrammetry and Remote Sensing, Falls Church, Virginia.
10. Siegel, B.S. and Gillespie, R. (1985): Remote Sensing in Geology. John Wiley and Sons, New York.
11. Spurr, R. (1960): Photogrammetry and Photo Interpretation. The Roland Press Company, London.
12. Survey of India, (1973): Photogrammetry. Survey of India, Dehradun.
13. Swain, P.H. and Davis, S.M. (ed.) (1978): Remote Sensing: The Quantitative Approach. McGraw- Hill, New York.
14. Wolf P.R. and Dewitt, B. A. (2000): Elements of Photogrammetry with Applications in GIS. McGraw-Hill, New York.

GMP 404. Elective (Major, Group III), Practical: 2.

Identification of objects and features; Determination of height of objects from single photographs and stereopairs; Preparation of thematic maps on lithology and structure, Geomorphology, Land use/ Land cover, Forest types, soil and soil erosion, Hydrogeomorphic mapping.

GIS: Geo-referencing; creation of PGDB, creation of shape files; on-screen digitization of polygons, points and lines and adding attributes

GME 405. Elective (Major, Group III), Theory: 3.
Satellite Image Interpretation

UNIT I

Fundamentals. Spectral characteristics of common natural objects; Atmospheric effects on remote sensing data; Spectral signatures and spectral response patterns; Resolutions of remote sensing data.

UNIT II

Sensors and Platforms. Indian Remote Sensing Satellites and sensors; Microwave remote sensing--SLAR and geometric characteristics of SLAR imagery.

UNIT III

Image Processing (IP) Techniques. Visual (VIP) and Digital (DIP); Image rectification/pre-processing operations; Image enhancement (contrast enhancement, spatial filtering and band ratioing); Image classification: supervised and unsupervised.

UNIT IV

Applications. Satellite image interpretation in terrain and resource mapping and evaluation; Lithology and structure; Land use/ land cover mapping; Forest types; Environmental monitoring; Remote sensing and GIS.

Books Recommended:

1. Campell, J. B. (2003): Introduction to Remote Sensing. 4th ed. Taylor and Francis, London.
2. Cracknell, A. and Ladson, H (1990): Remote Sensing Year Book. Taylor and Francis, London.
3. Curran, P.J. (1985): Principles of Remote Sensing. Longman, London.
4. Deekshatulu, B.L. and Rajan, Y.S. (ed.) (1984): Remote Sensing. Indian Academy of Science, Bangalore.
5. Floyd, F. and Sabins, Jr. (1986): Remote Sensing: Principles and Interpretation. W.H. Freeman, New York.
6. Gautam, N.C. and Raghavswamy, V. (2004): Land Use/ Land Cover and Management Practices in India. B.S. Publications., Hyderabad.
7. Harry, C.A. (ed.) (1987): Digital Image Processing. IEEE Computer Society, California.
8. Hord, R.M. (1982): Digital Image Processing of Remotely Sensed Data. Academic Press, New York.
9. Jensen, J.R. (1986): Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice-Hall, Englewood Cliffs, New Jersey.
10. Jensen, J.R. (2004): Remote Sensing of the Environment: An Earth Resource Perspective. Prentice-Hall, Englewood Cliffs, New Jersey. Indian reprint available.
11. Lillesand, T.M. and Kiefer, R.W. (2000): Remote Sensing and Image Interpretation. John Wiley and Sons, New York.
12. Nag, P. (ed.) (2000): Thematic Cartography and Remote Sensing. Concept Publishing. Company, New Delhi.
13. Nag, P. and Kudrat, M. (1998): Digital Image Processing, Concept Publishing Company, New Delhi.

14. Rampal, K.K. (1999): Handbook of Aerial Photography and Interpretation. Concept Publishing. Company, New Delhi.
15. Reeves, R.G. (ed.) (1983): Manual of Remote Sensing, Vols. 1 and 2. American Society of Photogrammetry and Remote Sensing, Falls Church, Virginia.
16. Renz, A.N. (ed.) (1999): Remote Sensing for the Earth Sciences: Manual of Remote Sensing. American Society of Photogrammetry and Remote Sensing, and John Wiley and Sons, New York.
17. Siegel, B.S. and Gillespie, R. (1985): Remote Sensing in Geology. John Wiley and Sons, New York.
18. Swain, P.H. and Davis, S.M. (ed.) (1978): Remote Sensing: The Quantitative Approach. McGraw Hill, New York.

GMP 406. Elective (Major, Group III), Practical: 3
Satellite Image Interpretation

Preparation of keys from satellite images; Preparation of thematic maps on lithology and structure, geomorphology, land use/land cover, soils and soil erosion, forest types, hydro-geomorphologic mapping and ground water potential zones.

Digital Image Processing (DIP): Image enhancements; Georeferencing; Mosaic preparation; Image classification: supervised and unsupervised.

M.Sc. (Tech) GEOLOGY
Department of Geology
Banaras Hindu University

Semesterwise Courses and Credits

SEMESTER – I		
Course Code	**Title**	**Credits**
GLM101	Structural Geology and Tectonics	3
GLM102	Mineralogy and Crystallography	3
GLM103	Igneous Petrology	3
GLM104	Metamorphic Petrology and Thermodynamics	3
GLM105	Practicals connected with GLM101	2
GLM106	Practicals connected with GLM102	2
GLM107	Practicals connected with GLM103	2
GLM108	Practicals connected with GLM104	2
GLM109M #	Minor Elective: Earth System – Frontier areas (*for students of other PG Programmes*) Minor Elective: (for Geology students)	3
	TOTAL	**23**
SEMESTER – II		
GLM201	Geomorphology and Remote Sensing	3
GLM202	Sedimentology	3
GLM203	General and Invertebrate Paleontology	3
GLM204	Stratigraphy	3
GLM205	Geological Field Training	5
GLM206	Practicals connected with GLM201	2
GLM207	Practicals connected with GLM202	2
GLM208	Practicals connected with GLM203	2
GLM209	Practicals connected with GLM204	2
GLM210M #	Minor Elective: Life through ages (*for students of other PG Programmes*) Minor Elective: (for Geology students)	3
	TOTAL	**28**
SEMESTER – III		
GLM301	Coal Geology	3
GLM302	Ore Geology	3
GLM303	Hydrogeology	3
GLM304	Micropaleontology and Oceanography	3
GLM305	Practicals connected with GLM301	2
GLM306	Practicals connected with GLM302	2
GLM307	Practicals connected with GLM303	2
GLM308	Practicals connected with GLM304	2
GLM309M #	Minor Elective: Environmental Geology (*for students of other PG Programmes*) Minor Elective: (for Geology students)	3
	TOTAL	**23**
SEMESTER - IV		
GLM401	Petroleum Geology	3
GLM402	Geochemistry	3
GLM403	Geological Field Training	5
GLM404	Practicals connected with GLM401	2
GLM405	Practicals connected with GLM402	2
MAJOR ELECTIVE (any two of GLM406, 407 & GLM408 and corresponding practicals)		
GLM406	Mineral Exploration and Mineral Economics	3
GLM407	Basin Analysis	3
GLM408	Applicative Paleobiology	3
GLM409	Practicals connected with GLM406	2
GLM410	Practicals connected with GLM407	2
GLM411	Practicals connected with GLM408	2
	TOTAL	**25**

SEMESTER - V		
MAJOR ELECTIVE: GROUP-A (**any three of GLM501, GLM502, GLM503 & GLM504 and corresponding practicals**)		
Course no.	**Title**	**Credit**
GLM501	Marine Geology	3
GLM502	Environmental Geology and Natural Hazards	3
GLM503	Elements of Mining, Ore Dressing and Surveying	3
GLM504	Engineering Geology and Geophysical Exploration	3
GLM505	Practicals connected with GLM501	2
GLM506	Practicals connected with GLM502	2
GLM507	Practicals connected with GLM503	2
GLM508	Practicals connected with GLM504	2
MAJOR ELECTIVE: GROUP-B (**any three of GLM509 to GLM516**)		
GLM509	Applicative Paleobotany and Palynology	3
GLM510	Applied Vertebrate Paleontology	3
GLM511	Gemology	3
GLM512	Computer Application and Instrumentation in Geology	3
GLM513	Soil Geology	3
GLM514	Sequence Stratigraphy	3
GLM515	Planetary Geoscience	3
GLM516	Paleobiogeography and Plate Tetonics	3
	TOTAL	**24**
SEMESTER - VI		
GLM601	**PROJECT ORIENTED DISSERTATION**	**22**
	GRAND TOTAL	**145**

M.Sc. (Tech) Geology students will opt 3 Minor Electives (3 credit each in semester I, II & III) offered by other PG Programmes of Faculty.

M.Sc. (Tech.) GEOLOGY
DEPARTMENT OF GEOLOGY
BANARAS HINDU UNIVERSITY

Candidates who have passed the three year and/or six semester B.Sc. (Hons.) Geology examination of the Banaras Hindu University or any other equivalent examination of other universities with Geology as one of the subjects will be considered eligible for admission to the Six Semester M.Sc. (Tech.) Geology.

The M.Sc. (Tech.) Geology shall be imparted to students for three academic sessions consisting of six semesters as given below. Candidates will be examined and evaluated on grade basis at the end of each semester in the different courses of theory and practical as per credits given against each course. The M.Sc. (Tech.) Geology will consist of (a) Core Courses, (b) Major Elective Courses, (c) Minor Elective Courses, (d) Geological Field Training and (e) Project Oriented Dissertation.

a) The Core courses will be compulsory for all the students admitted to M.Sc. (Tech.) Geology. There will be fourteen core courses, each of 5 credits (3 credits for theory and 2 credits for practical) covering major branches of Geology.

b) There are seven major elective courses, each of 5 credits (3 credits for theory and 2 credits for practical). Out of the seven major elective courses, two courses shall have to be opted in Semester - IV and three in Semester – V.

c) The M.Sc. (Tech.) Geology incorporates fourteen minor elective courses, each of 3 credits. These include i) three compulsory minor electives (each of 3 credits) of other departments for students of M.Sc. (Tech.) Geology respectively in Semester – I, Semester – II and Semester – III , ii) eight minor electives, each of 3 credits (2 credits for theory and 1 credit for practical) out of which three minor elective courses shall have to be opted in Semester – V by M.Sc. (Tech.) Geology students and iii) three compulsory minor electives, each of 3 credits are for students of sister departments. Any major/minor elective course shall run if opted by at least 15% students.

d) The compulsory geological field training includes two to three weeks field work and associated viva -voce examination at the end of Semesters - II and – IV, each of 5 credits (3 credits for field training,1 credit for viva-voce and 1 credit for detailed field report). The field training and viva-voce examination will be conducted by at least two internal examiners (faculty members). The semester breaks can also be utilized for the geological field training.

e) Along with the above courses, there shall be a Project Oriented Dissertation of 22 credits. It envisages i) geological field work (7 credits), ii) periodic presentations (5 credits) and iii) submission of thesis and final presentation of 10 credits (8 and 2 credits respectively for thesis and presentation) .The area of Dissertation shall be assigned to the students at the end of Semester - IV based on the merit of the students and expertise available in the Department. The project oriented dissertation thesis must be submitted by the end of Semester – VI through detailed field work, laboratory investigations, periodic seminar presentation followed by final presentation before the faculty members and the board of examiners for the purpose of evaluation.

Marks for theory and practical examinations shall be as per the following.

Exam. Components	Marks for Semester Exam.	**Sessional** Intra Semester Test + class assignment and regularity	**Sessional** Intra-semester practical assessment + class assignment and regularity	Total Marks
Theory	70	30 (20+10)	-	100
Practical	70	-	30 (20+10)	100

SEMESTER - I

Course No. GLM101: STRUCTURAL GEOLOGY **Credit: 3**

Unit-1
Mechanical principles, properties of rocks and their controlling factors; Concept of stress; Theories of rock failure; Two-dimensional stress analyses; Causes and dynamics of faulting, strike-slip faults, normal faults, thrust faults; Thin-skinned deformation; Decollement.

Unit-2
Concept of strain, two dimensional strain analysis; Types of strain ellipses and ellipsoids, their properties and geological significance; Methods of strain measurements in naturally deformed rocks; Mechanics of folding and buckling, superposed folding patterns, fold development and distribution of strains in folds.

Brittle and ductile shear zones, geometry and products of shear zones; Mylonites and cataclasites; Planar and linear fabrics in deformed rocks, their origin and significance.

Unit-3
Basic idea about petrofabrics and use of universal stage; Stereographic and equal area projections for representing different types of fabrics, π and β diagrams; Geometrical analysis of simple and complex structures on macroscopic scale.

Unit-4
Paleomagnetism, polar wandering and reversal of earth's magnetic field; Geomagnetic time scale; Concept of plate tectonics, nature and types of plate margins, geometry and mechanism of plate motion; Island arcs and mountain chains, their global distribution and evolution; Orogenic and epeirogenic phases; Plate tectonic evolution of India.

Books Recommended:
Condie, Kent. C. (1982): Plate Tectonics and Crustal Evolution, Pergamon Press Inc.
Gass I.G. (1982): Understanding the Earth. Artemis Press (Pvt) Ltd. U.K.
Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Development. Pergamon Press.
Hobbs, B.E., Means, W.D. and Williams, P.F. (1976): An outline of Structural Geology, John Wiley and Sons, New York.
Ramsay, J.G. (1967): Folding and fracturing of rocks, McGraw Hill.
Ramsay, J.G. and Huber, M.I. (1983): Techniques of Modern Structural Geology, Vol. I, Strain Analysis, Academic Press.
Ramsay, J.G. and Huber, M.I. (1987): Techniques of Modern Structural Geology, Vol. II, Folds and Fractures, Academic Press.
Ramsay, J.G. and Huber, M.I. (2000): Techniques of Modern Structural Geology, Vol. III (Application of continuum mechanics), Academic Press.
Turner, F.J. and Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites, McGraw Hill.
Windley B. (1973): The Evolving continents, John Wiley and Sons, New York.

Course No. GLM102: MINERALOGY AND CRYSTALLOGRAPHY **Credit: 3**

Mineralogy

Unit-1
Introduction to crystal chemistry, bonding in minerals, solid solution, polymorphism, isomorphism, pseudomorphism; Pauling's rules governing the ionic structures.

Unit-2
A detailed study of following mineral groups with reference to their general formulae, classification, atomic structure, chemistry, experimental work and paragenesis:

a. Nesosilicates - Olivine group; Garnet group; Aluminosilicate group (kyanite, andalusite and sillimanite).
b. Cyclosilicates - Beryl
c. Inosilicates - Pyroxene group; Amphibole group.
d. Phyllosilicates - Kaolinite group; Serpentine group; Pyrophyllite, talc; Mica group; Chlorite group.

e.Tektosilicates - Feldspar group; Cordierite.

Crystallography and advanced mineral characterization techniques

Unit-3
Historical development of crystallography and its importance in mineralogy; Introduction to 32 classes of symmetry, description of holosymmetric class of various crystal systems, international system of crystallographic notation; Different types of crystal projections – spherical and stereographic, and their uses; Symmetry of internal structures – Bravais lattices; Twinning and twin laws, common types of twins and their examples in minerals; Liquid crystals and their applications.

Unit-4
Various sample preparation techniques in mineralogy; Historical development of X-ray crystallography and Bragg's equation, powder method in X-Ray crystallography; Electron probe micro analysis and scanning electron microscopy - principle, application and their utility in mineral sciences; Introduction to ion microprobe analysis and infra red spectroscopy; Introduction to mineral formulae calculation of important rock forming minerals.

Books Recommended:
Berry, L.G., Mason, B. and Dietrich, R.V. (1982): Mineralogy, CBS Publ.
Dana, E.S. and Ford, W.E.(2002): A textbook of Mineralogy (Reprint).
Kerr, P.F. (1977): Optical Mineralogy, McGraw Hill.
Moorhouse, W.W. (1951): Optical Mineralogy, Harper and row Publ.
Nesse, D.W. (1986): Optical Mineralogy, McGraw Hill.
Perkins, D. (1998): Mineralogy, Prentice Hall.
Phillips, F.C (1971): Introduction to Crystallography,Longman Group Publ.
Winchell, E.N. (1951): Elements of Optical Mineralogy, Wiley Eastern.

Course No. GLM103: IGNEOUS PETROLOGY **Credit: 3**

Unit-1
Nature and evolution of magma; Introduction to mantle petrology and mantle metasomatism, mantle heterogeneities; Plate tectonics and generation of magmas; Phase equilibrium - binary systems (Ab-An, Ab-Or, Di-An, Fo-Si) and their relations to magma genesis and crystallization in the light of modern experimental works.

Unit-2
Ternary systems (Di-Ab-An, Di-Fo-Si, Di-Fo-An, Ne-Ks-Si, Fo-An-Si) and their relations to magma genesis and crystallization in the light of modern experimental works; Interpretation of igneous textures in terms of rate of nucleation and crystal growth.

Unit-3
IUGS classification of the igneous rocks and CIPW norm; Petrology and petrogenesis of major igneous rock types with Indian examples of ultramafic, komatiite, basalt, granite, alkaline rocks, ophiolite, bornite, carbonatite, lamprophyre, lamproite, and kimberlite.

Unit-4
Plume magmatism and hot spots; Large igneous provinces and mafic dyke swarms; Partial melting (batch and fractional melting); Crystal fractionation (equilibrium and fractional (Rayleigh) crystallization); Contamination (AFC process) and dynamic melting.

Books recommended:
Bose, M.K. (1997): Igneous Petrology, World Press, Kolkata.
Best, Myron G. (2002): Igneous and Metamorphic Petrology, Blackwell Science.
Cox, K.G., Bell, J.D. and Pankhurst, R.J. (1993): The Interpretation of Igneous Rocks, Champman and Hall, London.
Faure, G. (2001): Origin of Igneous Rocks, Springer.

Hall, A. (1997): Igneous Petrology, Longman.
LeMaitre R.W. (2002): Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press.
McBirney (1994): Igneous Petrology, CBS Publ., Delhi.
Phillpotts, A.R. (1994): Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
Sood, M.K. (1982): Modern Igneous Petrology, Wiley-Interscience Publ., New York.
Srivastava, Rajesh K. and Chandra, R., (1995): Magmatism in Relation to Diverse Tectonic Settings, A.A. Balkema, Rotterdam.
Wilson, M. (1993): Igneous Petrogenesis, Chapman and Hall, London.
Winter, J.D. (2001): An Introduction to Igneous and Metamorphic Petrology, Prentice Hall, New Jersey.

Course No. GLM104: METAMORPHIC PETROLOGY AND THERMODYNAMICS Credit: 3

Unit-1
Mineralogical phase rule for closed and open systems; Nature of metamorphic reactions; Concept and classification of metamorphic facies and facies series; Introduction to ultrahigh temperature and ultrahigh pressure metamorphism.

Unit-2
Description of each facies of low, medium to high pressure and very high pressure with special reference to characteristic minerals, subdivision into zones/subfacies, mineral assemblages; Metamorphic reactions and pressure – temperature conditions of metamorphism.

Unit-3
Isograds and reaction isograds; Schrienemakers rule and construction of petrogenetic grids; Metamorphic differentiation, anatexis and origin of migmatites in the light of experimental studies; Regional metamorphism and paired metamorphic belts with reference to the theory of plate tectonics; Pressure – temperature – time paths.

Unit-4
Laws of thermodynamics; Gibb's free energy, entropy; Δ G of metamorphic reactions (solid-solid and dehydration reactions); Clausius – Clapeyron equation; Geothermobarometry.

Books Recommended:
Blatt, H. and Tracy, R.J. (1996): Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman and Co., NewYork.
Bucher, K. and Martin, F. (2002): Petrogenesis of Metamorphic Rocks (7^{th} Rev. Ed.), Springer–Verlag,.
Kerr, P.F. (1959): Optical Mineralogy, McGraw Hill Book Company Inc., New York.
Philpotts, A.R. (1994): Principles of Igneous and Metamorphic Petrology, Prentice Hall.
Powell, R. (1978): Equilibrium thermodynamics in Petrology: An Introduction, Harper and Row Publ., London.
Rastogy, R.P. and Mishra, R.R. (1993): An Introduction to Chemical Thermodynamics, Vikash Publishing House.
Spear, F. S. (1993): Mineralogical Phase Equilibria and pressure – temperature – time Paths, Mineralogical Society of America.
Spry, A. (1976): Metamorphic Textures, Pergamon Press.
Winter, J.D. (2001): An introduction to Igneous and Metamorphic Petrology, Prentice Hall.
Wood, B.J. and Fraser, D.G. (1976): Elementary Thermodynamics for Geologists, Oxford University Press, London.
Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995): Atlas of Metamorphic Rocks and their textures, Longman Scientific and Technical, England.
Yardlley, B.W.D. (1989): An introduction to Metamorphic Petrology, Longman Scientific and Technical, New York.

Course No. GLM105: Practicals (connected with GLM101) Credit: 2

Preparation and interpretation of geological maps and sections; Structural problems concerning economic deposit based on orthographic and stereographic projections; Recording and plotting of the field data; Study of deformed structures in hand specimens; Strain estimation from the data already collected from the field; Study of dip-isogons from the fold profiles; Preparation of geotectonic maps.

Course No. GLM106: Practicals (connected with GLM102) **Credit: 2**

Mineralogy
Identification of rock forming minerals in hand specimens; Mineral formulae, calculation of important rock forming mineral groups; Microscopic identification of important rock forming minerals; Determination of length-fast and length-slow character of minerals; Determination of pleochroic scheme; Study of interference figures of uniaxial and biaxial minerals and determination of optic sign.

Crystallography
Use of goniometer and calculation of axial ratio; Stereographic projection of crystals.

Course No. GLM107: Practicals (connected with GLM103) **Credit: 2**

Megascopic and microscopic study of different igneous rocks; Calculation of CIPW norms.

Course No. GLM108: Practicals (connected with GLM104) **Credit: 2**

A detailed study of textures in rock sections with reference to time relations between the phases of deformation and recrystallization of minerals; Calculation of ACF, AKF and AFM values from chemical and structural formulation of minerals and their graphical representation; Study of metamorphic rocks in thin sections belonging to different facies with emphasis on texture/structure, mineral composition, parent rock, metamorphic facies/subfacies/zone to which the rock can be assigned and graphical representation of the assemblage in ACF, AKF and AFM diagrams; Study of metamorphic rocks of different metamorphic facies in hand specimens; Estimation of pressure and temperature from important models of geothermobarometry.

Course No. GLM109M: Earth System – Frontier areas (minor elective) **Credit: 3**

Unit 1
Geology and its perspective; Earth in the solar system - origin, size, shape, mass, density; Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere and elemental abundance in each constituent.

Unit 2
Convection in the earth's core and production of earth's magnetic field; Magnetic polarity reversal; Radioactivity and age of the earth; Earthquakes and volcanoes.

Unit 3
Orogenic and epiorogenic phases, evidence of continental drift, and sea floor spreading; Origin and significance of mid oceanic ridges and trenches.

Unit 4
Plate Tectonics, nature and types of plate margins, evolution of oceans, continents and mountains.

Books Recommended:
Holmes, Arthur (1992): Principles of Physical Geology, Vol. 1, Chapman and Hall, London.
Leet, L.D. and Judson, S. (1969): Physical Geology, Prentice Hall.
McBride, N. and Gilmour, I (2003): An Introduction to the Solar System, Cambridge Univ. Press.
Ruhe, R.V. (1975): Geomorphology, Houghton Miffin Co., Boston.
Sparks (1960): Geomorphology, Longmans.

SEMESTER - II

Course No. GLM-201: GEOMORPHOLOGY AND REMOTE SENSING **Credit: 3**

Geomorphology

Unit-1
Basic concepts and significance of geomorphology; Cycle of erosion, fluvial landforms and drainage patterns; Evolution of landforms in aeolian, marine, glacial and karst landscapes; An elementary idea about morphogenesis and morphography; Morphometric analysis, morphochronology; Neotectonics - geomorphological indicators, active faults, drainage changes, recurrent seismicity.

Unit-2
Geomorphology of India - Peninsular, Extra-peninsular and Indo-Gangetic plains; Application of geomorphology in mineral prospecting, civil engineering, military purposes, hydrogeology and environmental studies.

Remote Sensing

Unit-3
Electromagnetic radiation – characteristics, remote sensing regions and bands; General orbital and sensor characteristics of remote sensing satellites; Spectra of common natural objects – soil, rock, water and vegetation.

Aerial photos – types, scale, resolution, properties of aerial photos, stereoscopic parallax, relief displacement; Digital image processing - characteristics of remote sensing data, preprocessing, enhancements, classification; Elements of photo and imagery pattern and interpretation, application in Geology; Remote sensing applications in interpreting structure and tectonics; Lithological mapping, mineral resources, groundwater potentials and environmental monitoring.

Unit-4
Principles and components of GIS, remote sensing data integration with GIS, applications of GIS in various geological studies.

Books recommended:
Drury, S.A. (2001): Image Interpretation in Geology, Allen and Unwin.
Gupta, R.P. (1991): Remote Sensing Geology, Springer-Verlag.
Halis, J.R. (1983): Applied Geomorphology.
Holmes,A.(1992): Holmes Principles of Physical Geology, Edited by P. McL. D. Duff. Chapman and Hall.
Lillesand, T.M. and Kiefer, R.W. (1987): Remote Sensing and Image Interpretation, John Wiley.
Sharma, H.S. (1990): Indian Geomorphology, Concept Publishing Co., New Delhi.
Siegal, B.S. and Gillespie, A.R. (1980): Remote Sensing in Geology, John Wiley.
Thornbury, W.D. (1980): Principles of Geomorphology, Wiley Easton Ltd., New York.

Course No. GLM202: SEDIMENTOLOGY **Credit: 3**

Unit-1
Texture - shape, size, fabric and surface textures, methods of textural analysis, textural parameters and their significance.

Unit-2
Petrogesis of sandstones, Graywacke and graywacke problem; plate - tectonics and sandstones composition; Argillaceous rocks, their classification and genesis.

Unit-3
Dolomites, their petrographic characteristics and models of dolomitization; Study of evaporites such as gypsum, anhydrite and halite; Detailed study of siliceous, phosphatic and ferruginous rocks; Diagenesis - physical and chemical, processes and evidences of diagenesis in sandstones, mud rocks and carbonate rocks.

Unit-4
Fluid flow mechanics and formation of sedimentary bedforms; Implication of facies in environmental interpretation and basin analysis.

Books Recommended:
Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks, Prentice-Hall Inc.
Collins, J.D., and Thompson, D.B. (1982): Sedimentary Structures, George Allen and Unwin, London.
Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.
Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag.
Pettijohn;, F.J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.
Reading, H.G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication.
Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag.
Selley, R. C. (2000) Applied Sedimentology, Academic Press.
Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
Tucker, M.E. (1990): Carbonate Sedimentolgy, Blackwell Scientific Publication.

Course No.GLM203: GENERAL AND INVERTEBRATE PALEONTOLOGY Credit: 3

General and Systematics

Unit-1
Modern systematics; Concept and kind of type specimens; Trans-specific evolution, speciation and radiation; Classification of Brachiopoda, Bivalvia and Cnidaria corals.

Unit -2
Evolutionary trends and geological history of Ammonoidea and Trilobita; Ichnofossils, their modes of preservation, behavioral classification and ichnofacies.

Applicative

Unit-3
Approaches to paleoecological and paleoenvironmental studies based on benthic communities, trace fossils and taphonomic record with Indian examples; Micro and macro-evolution, types of heterochrony in evolutionary lineages, and their application to biochronology with Indian examples.

Unit - 4
Distribution, migration and dispersal of organisms applied to paleobiogeography and plate-tectonics with Indian examples; Intra-basinal to regional spatio-temporal distribution of fossil record applied to sequence stratigraphy, depositional environment and basin analysis with Indian examples.

Books Recommended:
Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988): Fossil Invertebrates, Blackwell.
Clarksons, E.N.K. (1998): Invertebrate Paleontology and Evolution, Allen and Unwin, London.
Dobzhansky, Ayala, Stebbins and Valentine (1977): Evolution, Freeman.
Horowitz, A.S. and Potter, E.D. (1971): Introductory Petrography of Fossils, Springer Verlag.
Mayr, E. (1971): Population, Species and Evolution, Harvard.
Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
Raup, D.M. and Stanley, S.M. (1985): Principles of Paleontology ,CBS Publ..
Smith, A.B.(1994): Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
Strean, C.W. and Carroll, R.L. (1989): Paleontology – the record of life, John Wiley.

Course No. GLM204: STRATIGRAPHY Credit: 3

General and Precambrian stratigraphy

Unit-1
Approaches to measurement of geological time; Concept of sequence stratigraphy; brief ideas of magneto-seismic- chemo- and event stratigraphy; Stratigraphic correlations; Approaches to paleogeography.

Precambrian geochronology; Precambrian chronostratigraphy of Rajasthan, Dharwar craton, Eastern Ghat belt, Southern Granulite belt and Singhbhum-Chotanagpur-Orissa belt; Proterozoic stratigraphy of Son valley, Cuddapah and Kurnool basins; Precambrian/Cambrian boundary.

Marine Palaeozoic and Gondawana stratigraphy

Unit- 2
Igneous activities and paleogeography during the Palaeozoic era; Stratigraphy, facies, and fossil contents of the Palaeozoic rock formations of India; Permian/Triassic boundary.

Concept, classification, fauna, flora and age limits of Gondwana supergroup and related paleogeography, paleoclimate, depositional characteristics and igneous activities.

Mesozoic and Cenozoic stratigraphy

Unit- 3
Classification, depositional characteristics, fauna, and flora of Triassic, Jurassic and Cretaceous systems in principal basins of India; Cretaceous/Tertiary boundary.

Unit- 4
Classification, depositional characteristics, fauna, and flora of the Palaeogene and Neogene systems in their type localities and their equivalents in India; Epoch boundaries of the Cenozoic in India.

Books Recommended:
Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall.
Danbar, C.O. and Rodgers, J. (1957): Principles of Stratigraphy, John Viley and Sons.
Doyle, P. and Bennett. M.R. (1996): Unlocking the Stratigraphic Record, John Viley and Sons.
Krishnan,M.S. (1982): Geology of India and Burma, C.B.S. Publ. and Distributors, Delhi.
Naqvi, S.M. and Rogers, J.J.W. (1987): Precambrian Geology of India, Oxford University Press.
Pascoe, E.H. (1968): A Manual of the Geology of India and Burma (Vols.I-IV), Govt. of India Press, Delhi.
Pomerol, C. (1982): The Cenozoic Era? Tertiary and Quaternary, Ellis Harwood Ltd., Halsted Press.
Schoch, Robert, M. (1989): Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.

Course No. GLM205: GEOLOGICAL FIELD TRAINING **Credit: 5**

Course No. GLM206: Practicals (connected with GLM201) **Credit: 2**

Drainage and slope morphometry, hypsometry; Geomorphology through topo-sheets, aerial photos and satellite imagery; Terrain aspect mapping; Determination of scale in aerial photos, measurement of heights of objects from aerial photos, study and interpretation of single and stereo pair aerial photos; Preparation of interpretation keys, thematic mapping from aerial photos and satellite images – structure, lithology, landforms, minerals, soils, groundwater; Application of GIS in geological studies.

Course No. GLM207: Practicals (connected with GLM202) **Credit: 2**

Detailed study of clastic and non-clastic rocks in hand specimens; Study of assemblages of sedimentary structures in context of their paleoenvironmental significance; Microscopic examination of important rock-types; Heavy mineral separation, their microscopic characters, graphic representation and interpretation; Grain-size analysis by sieving method; Plotting of size-distribution data as frequency and cumulative curves, computation of statistical parameters and interpretation.

Course No. GLM208: Practicals (connected with GLM203) **Credit: 2**

Study of the morphological characters of some important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and corals; Determination of valves and dental formula of heterodont bivalves; Shell petrography of bivalves and brachiopods; Study of an assorted group of

trace fossils; Study of ammonoid suture pattern, coiling, whorl section and ontogenic variation; Exercises in ammonoid heterochrony; Measurements of dimensional parameters and preparation of elementary bivariate growth curves and scatter plots.

Course No. GLM209: Practicals (connected with GLM204) **Credit: 2**

Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities; Exercises on stratigraphic classification and correlation, sequence, magneto and seismic stratigraphic interpretations; Study and understanding of plate-movements through important periods during Phanerozoic Eon; Evolution of ocean systems during Phanerozoic.

Course No. GLM210M: LIFE THROUGH AGES (minor elective) **Credit: 3**

Unit -1

Biosphere; Modern thoughts on origin of life; Chief characteristic of major phyla of organic world; Nature of primitive life (invertebrate, vertebrate and plants).

Unit -2

Rise and fall of dinosaurs; First flying birds; Mammalian explosion; Chance, coincidence and chaos in human evolution.

Unit -3

Mass extinctions, processes, causes and evidences; Ice age.

Unit -4

Techniques of dating ancient life; Relative dating - cultural affiliation, pollen analysis, varve analysis, rate of accumulation; Absolute dating - dendrochronology, recimization, oxidized carbon ratio, archeomagnetism; Potassium-Argon dating.

Books Recommended:

Egan, C. and Odier, G. (2006): The Jurassic Mammal Explosion, Victoria, BC, Trafford.
Garylane, N. (1986): Life of Past S.K. Donovan -Mass Extinction: Process and Evidences.
Knight, C.R. (2001): Life through Ages, Indiana Univ. Press.
Norman, D. (1992): Dinosaurs, New York.
Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
Tarling,D.H (1984): Paleomagnetism: Principles and Applications in Geology, Geophysics and Archaeology, Chapman and Hall.

SEMESTER - III

Course No. GLM301: COAL GEOLOGY **Credit: 3**

Unit -1

Definition and origin of coal; Sedimentology of coal bearing strata; Types of seam discontinuities and structures associated with coal seams; Chemical analysis of coal (proximate and ultimate analysis).

Unit -2

Coal Petrology – concept of 'lithotype', 'maceral' and 'microlithotype; Classification and optical properties of macerals and microlithotypes; Techniques and methods of coal microscopy; Elementary knowledge of the application of reflectance and fluorescence microscopy; Applications of coal petrology.

Unit- 3

Classification of coal in terms of rank, grade and type; Indian classification for coking and non-coking coals; International classifications (I.S.O. and Alpern's classification); Elementary idea about coal preparation, coal carbonization, coal gasification, underground coal gasification (UCG), coal hydrogenation and coal combustion.

Unit -4

Coal Bed Methane (CBM) – An unconventional petroleum system; Elementary idea about generation of methane in coal beds; coal as a reservoir and coal bed methane exploration; Coal as a source rock for oil and

gas; Geological and geographical distribution of coal and lignite deposits in India; Coal exploration and estimation of coal reserves; Indian coal reserves and production of coal in India.

Books Recommended:

Chandra, D., Singh, R.M. Singh, M.P. (2000): Textbook of Coal (Indian context), Tara Book Agency, Varanasi.
Scott, A.C. (1987): Coal and Coal-bearing strata: Recent Advances, Blackwell Scientific Publications.
Singh, M.P. (1998): Coal and organic Petrology, Hindustan Publishing Corporation, New Delhi.
Stach;, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R. (1982): Stach Texbook of Coal petrology, Gebruder Borntraeger, Stuttgart.
Taylor,G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert P. (1998): Organic Petrology, Gebruder Borntraeger, Stuttgart.
Thomas, Larry (2002): Coal Geology, John Wiley and Sons Ltd., England.
Van Krevelen, D. W. (1993): Coal :Typology-Physics-Chemistry-Constitution), Elsevier Science, Netherlands.

Course No. GLM302: ORE GEOLOGY **Credit: 3**

Unit-1

Concept of ore bearing fluids, their origin and migration; Wall rock alteration; Structural, physicochemical and stratigraphic controls of ore localization; Ore deposits in relation to plate tectonics; Organic matters in ores and their significance; Fluid inclusions in ore - principles, assumptions, limitations and applications.

Unit-2

Mineralogy, classification and genesis of ore deposits associated with orthomagmatic ores of ultramafic-mafic rocks; Ores of felsic-silicic igneous rocks; Ores of sedimentary affiliation - biochemical, chemical and clastic sedimentation, placers and residual concentration deposits; Ores of metamorphic affiliations.

Unit-3

Study of ore minerals related to the following metals with special reference to their mineralogy, genesis, specification (if any), uses and distribution in India:
Fe, Mn, Cr, Cu, Pb, Zn. Al, Mg, Sn, and W.

Unit-4

Introduction to ore microscopy, techniques, methods, textures and microstructures of ores, interpretation of ore texture and optical properties of common sulphide, oxide ore minerals; Industrial application of ore microscopy.

Books Recommended:

Branes, H.L. (1979): Geochemistry of Hydrothermal Ore Deposits, John Willey.
Cuilbert, J.M. and Park,Jr. C.F.(1986): The Geology of Ore Deposits, Freidman.
Evans, A.M. (1993): Ore Geology and Industrial Minerals, Blackwell.
James R. Craig and David J.Vaughan (1994): Ore Microscopy and Petrography.
Klemm, D.D. and Schnieder, H.J. (1977): Time and Strata Bound Ore Deposits, Springer-Verlag.
Mookherjee, A. (2000): Ore Genesis-A Holistic Approach, Allied Publisher.
Ramdhor, P. (1969): The Ore Minerals and their Intergowths, Pergamon Press.
Stanton, R.L. (1972): Ore Petrology, McGraw Hill.
Wolf, K.H. (1976-1981): Hand Book of Stratabound and Stratiform Ore Deposits, Elsevier Publ..

Course No. GLM303: HYDROGEOLOGY **Credit: 3**

Unit-1

Role of groundwater in the hydrological cycle; Controls of geology on groundwater occurrence and distribution; Classification of aquifers and aquifer systems, geological formations as aquifers; Mode of occurrence of groundwater in different geological terrains of India; Bernoulli's equation and hydraulic head; Darcy's law and Reynolds number; Hydraulic conductivity, transmissivity, storage coefficient and specific capacity; Water table contour maps and flow net analysis.

Unit-2

Pump tests and evaluation of hydrologic properties through various methods for steady and unsteady flow; Chemical characteristics of groundwater in relation to various uses – domestic, industrial and irrigation; Saline

water intrusion in coastal and other aquifers and its prevention; Radioisotopes in hydro-geological studies; Groundwater contamination and problems of arsenic, fluoride and nitrates.

Unit -3

Causative factors of groundwater level fluctuations and environmental influences; Artificial recharge to groundwater and rainwater harvesting; Management of groundwater resources; Conjunctive use of groundwater and surface water; Groundwater problems and management related to foundation work, mining, reservoirs, tunnels and effects of water in landslides; Environmental effects of over-exploitation of groundwater; Water logging problems; Groundwater legislation.

Unit - 4

Groundwater exploration; Geological and surface geophysical methods for the selection of suitable site for well construction; Type and design of wells, methods of well construction, well completion and well development.

Books Recommended:

C.F. Tolman (1937): Groundwater, McGraw Hill , New York and London.
D.K. Todd (1995): Groundwater Hydrology, John Wiley and Sons.
F.G. Driscoll (1988): Groundwater and Wells, UOP, Johnson Div.St.Paul. Min. USA.
H.M. Raghunath (1990): Groundwater, Wiley Eastern Ltd.,
H.S. Nagabhushaniah (2001): Groundwater in Hydrosphere (Groundwater hydrology), CBS Publ..
K. R. Karanth (1989): Hydrogeology, Tata McGraw Hill Publ..
S.N. Davies and R.J.N. De Wiest (1966): Hydrogeology, John Wiley and Sons, New York.

Course No. GLM304: MICROPALEONTOLOGY AND OCEANOGRAPHY Credit: 3

Micropaleontology

Unit-1

Definition and scope of the subject; Relationship of micropaleontology with ocean sciences; Modern field and laboratory techniques in the study of microfossils (collection, sampling and processing techniques, scanning electron microscopy and mass spectrometry); A brief account of the concepts and methods for the development of micropaleontological indicators useful in reconstruction of history of past, environmental changes and biostratigraphic correlation.

Types of Microfossils

Calcareous Microfossils:

(i) Foraminifera - planktic foraminifera, their modern biogeography, outline of morphology, significance in Cenozoic oceanic biostratigraphy and paleoceanographic, paleoclimatic interpretations; Benthic foraminifera - their brief morphology and application in bottom water paleoceanography and paleobathymetric reconstructions; Larger foraminifera, their outline of morphology and application in Indian stratigraphy; (ii) Calcareous nannofossils - outline of morphology, modern biogeography and their application in oceanic biostratigraphy and paleoceanographic, paleoclimatic reconstructions; (iii) Ostracoda - Outline of morphology and wall structure, their significance in environmental studies and oceanic biostratigraphy; (iv) Pteropoda - a brief introduction, application of pteropods in reconstruction of the Quaternary oceanography and climate; A brief introduction of calpionellids and calcareous algae.

Siliceous Microfossils:

Radiolaria, diatoms and silicoflagellate - outline of morphology, modern biogeography, their environmental significance and application in biostratigraphy.

Phosphatic Microfossils:

Conodonts - outline of morphology, paleoecology, geological significance and biological affinities; Stratigraphic significance of conodonts with special reference to India.

Unit-2

Organic Walled Microfossils:

Organic walled microfossils and their significance, outline morphology of spores, pollen, dinoflagellates and acritarchs; Factors controlling distribution of dinoflagellates, biostratigraphic significance of spores, pollen, dinoflagellates and acritarchs; Types of organic matters, concept of palynofacies and its application in paleoenvironment interpretation.

Application:

Micropaleontology in petroleum exploration; Environmental significance of microfossils; Geochemical study of microfossil tests (stable isotopes, radiocarbon isotopes and elemental composition) and its application in

paleoceanography and paleoclimatology and tracing history of marine pollution; Determination and correlation of paleofacies by microfossils; Interpretaion of sea floor tectonism from micropaleontological evidence; Application of palynology in identifying ancient coast lines; Role of micropaleontology in marine geology and oceanography.

Oceanography

Unit-3
History of development of oceanography; Sampling of modern ocean biogenic flux including sediment trap sampling; Methods of measuring properties of sea water; Temperature and salinity distribution (horizontal and vertical) in ocean waters; Dissolved gases in sea water, factors affecting the concentration of gases in sea water; Carbon dioxide equilibria, precipitation and dissolution of carbonates; Biological - chemical - physical interactions in the oceans; Oxygen minimum layer in the ocean.

Unit-4
Scientific ocean drilling and its major accomplishments; Ocean circulation, surface circulation; Concept of mixed layer, thermocline and pychnocline, Coriolis force and Ekman spiral, upwelling, El nino, deep ocean circulation, concept of thermohaline circulation, formation of bottom waters, water masses of the world oceans, oceanic sediments.

Books recommended:
Alfred Traverse (1988): Paleopalynology, Unwin Hyman, USA.
Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford University Press, New York.
Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontoogy, London.
David Tolmazin (1985): Elements of Dyanamic Oceanography, Allen and Unwin
Grant Gross, M. (1977): Oceanography; A view of the Earth, Prentice Hall.
John Houghton (1997): Global Warming, Cambridge Univ. Press.
Jones, T.P. and Rowe, T.P. (1999): Fossil plants and spores, Modern Techniques, Geological Soc. of London.

Course No. GLM305: Practicals (connected with GLM301) **Credit: 2**

Macroscopic characterization of banded coals; Completion of outcrop in the given maps and calculation of coal reserve; Preparation of polished particulate mounts of coal; Microscopic examination of polished particulate mounts (identification of macerals); Proximate analysis of coal.

Course No. GLM306: Practicals (connected with GLM302) **Credit: 2**

Megascopic study of Indian metallic ores and industrial minerals in hand specimens; Study of ore structures in hand specimens; Study of optical properties and identification of important ore minerals under ore-microscope; Preparation of maps showing distribution of metallic and industrial minerals in India and also classical world mineral deposits.

Course No. GLM307: Practicals (connected with GLM303) **Credit: 2**

Delineation of hydrological boundaries on water table contour maps; Laboratory estimation of water quality parameters; Presentation of chemical data and their uses in different purposes; Determination of activity coefficient of ions from Debye-Huckel equation and calculation of saturation index; Estimation of aquifer (hydrologic) properties such as hydraulic conductivity, transmissivity and storage coefficient.

Course No. GLM308: Practicals (connected with GLM304) **Credit: 2**

Micropaleontology
Techniques of separation of microfossils from matrix; Types of microfossils - calcareous, siliceous, phosphatic and organic walled microfossils; SEM applications in micropaleontology; Study of surface ultrastructures of foraminifera; Study of important planktic foraminifera useful in surface water, paleoceanography and oceanic biostratigraphy; Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India; Important palynomorphs of Cretaceous and Paleogene age.

Oceanography
Depth biotopes and estimation of palelodepth of the ocean using benthic foraminiferal assemblages; Identification of modern and ancient surface water mass with the help of planktic foraminiferal assemblages; Identification of benthic foraminifera characteristic of low oxygen environment; Identification of Planktic foraminifera characteristic of warm and mixed layer, thermocline and deep surface water of the modern oceans; Study of modern surface water, mass assemblages of planktic foraminifera from Indian ocean, Atlantic ocean and Pacific ocean.

Course No. GLM309M: ENVIRONMENTAL GEOLOGY (Minor Elective) Credit: 3

Unit -1
Fundamentals of environmental geology; Domains of environment and its relationship with earth system; Earth surface processes – weathering and erosion; Development of different types of landforms and soil profiles.

Unit -2
Composition and characteristics of terrestrial and marine environment; Types of supra-crustal rocks and their interaction with surface and ground water; Surface and ground water pollution and their major causes; Environmental pollution as a consequence of mining, processing and utilization.

Unit -3
Earthquake and tsunami – causes of occurrence and their impact as natural hazard; Natural hazard associated with volcanic eruptions.

Unit -4
Major river belts of India, flood hazards and their mitigation; Landslides and avalanches – causes and mitigation.

Books Recommended:
Bryant, E. (1985): Natural Hazards, Cambridge Univ. Press.
Keller, E.A.(1978): Environmental Geology, Bell and Howell, USA.
Nagabhushaniah, H.S. (2001): Goundwater in Hydrosphere, CBS Publ.
Perry, C.T. and Taylor, K.G. (2006): Environmental Sedimentology, Blackwell Publ.
Singh, S. (2001): Geomorphology, Pustakalaya Bhawan, Allahabad.
Todd, D.K. (1995): Groundwater Hydrology, John Wiley and Sons.
Valdiya, K.S.(1987): Environmental Geology – Indian Context, Tata McGraw Hill.

SEMESTER - IV

Course No. GLM401: PETROLEUM GEOLOGY Credit: 3

Unit -1
Petroleum – its composition, origin (formation of source rocks - kerogen, organic maturation and thermal cracking of kerogen); Migration of petroleum; Reservoir rocks - petrology of reservoir rocks, porosity and permeability; Reservoir traps – structural, stratigraphic and combination traps.

Unit -2
Petroleum exploration; Identification and characterization (petrographic and geochemical) of petroleum source rocks; Amount, type and maturation of organic matter; Oil and source rock correlation; Locating petroleum prospects based on principles of petroleum generation and migration (geological modeling).

Unit -3
Elementary knowledge of geophysical methods in exploration; Magnetic, gravity and seismic methods; Elementary knowledge of well drilling, cable-tool drilling, rotary drilling and various types of drilling units; Elementary knowledge of logging, electric, radioactive and sonic logs; Application of logs in petrophysical and facies analyses.

Unit- 4

An outline of the oil belts of the world; Onshore and offshore petroliferous basins of India; Geology of productive oilfields of India; Elements of unconventional petroleum systems; Basin-centered gas, fractured-shale gas system, shallow biogeneic gas and natural gas hydrates.

Books Recommended:

Barker, C. (1996): Thermal Modeling of Petroleum Generation, Elsevier Science, Netherlands.
Holson, G.D. and Tiratso, E.N. (1985): Introduction of Petroleum Geology, Fulf Publishing, Houston, Texas.
Hunt, J.M. (1996): Petroleum Geochemistry and Geology (2nd Ed.), Freeman, San Francisco.
Jahn, F., Cook, M. and Graham, M. (1998): Hydrocarbon exploration and production, Eslevier Science.
Makhous, M. (2000): The Formation of Hydrocarbon Deposits in North African Basins, Geological and Geochemical Conditions, Springer–Verlag.
North, F.K. (1985): Petroleum Geology, Allen Unwin.
Selley, R.C. (1998): Elements of Petroleum Geology, Academic Press.
Tissot, B.P. and Welte, D.H. (1984): Petroleum Formation and Occurrence, Springer–Verlag.

Course No. GLM402: GEOCHEMISTRY **Credit: 3**

Unit-1

Introduction and principles of geochemistry; Introduction, chemical composition and properties of atmosphere, hydrosphere and lithosphere; Geochemial cycles; Concepts of biogeochemical cycle; Geochemical classification of elements; Periodic table with special reference to transition and trace (including rare-earth) element geochemistry.

Unit-2

Stable isotope geochemistry of carbon and oxygen and its applications to geology; Radiogenic isotopes; Decay scheme of K-Ar, U-Pb and Rb–Sr and Sm-Nd; Petrogenetic implications of Sm-Nd, Rb-Sr; Radiometric dating of single minerals and whole rocks.

Unit-3

Element partitioning in mineral/rock formation and concept of distribution coefficient; Mineral stability in Eh-Ph diagrams; Sampling procedures and introduction to analytical techniques used in geochemistry; A brief introduction to geochemistry of natural waters and sedimentary rocks; Geochemical processes involved in rock weathering and soil formation; Principles of ionic substitution in minerals.

Unit-4

Crystal structure of some simple compounds – AX structures (NaCl, CsCl, ZnS, NiAs), AX_2 structure (fluorite, rutile); A brief idea about some other commpounds such as A_2X_3 (corrundum), ABX_3 (calcite, ilmenite) and AB_2X_4 (Spinel).

Books Recommended:

Bloss, F.D. (1971): Crystallography and Crystal Chemistry, Holt, Rinehart, and Winston, New York.
Evans, R.C., (1964): Introduction to Crystal Chemistry, Cambridge Univ. Press.
Hoefs, J. (1980): Stable Isotope Geochemistry, Springer-Verlag.
Klein, C. and Hurlbut, C.S. (1993): Manual of Mineralogy, John Viley and Sons, New York.
Krauskopf, K.B. (1967): Introduction to Geochemistry, McGraw Hill.
Mason, B. and Moore, C.B. (1991): Introduction to Geochemistry, Wiley Eastern.
Rollinson, H.R. (1993): Using geochemical data: Evaluation, Presentation, Interpretation. Longman U.K.
Shikazono, N. (2003): Geochemical and Tectonic Evolution of Arc-Backarc Hydrothermal Systems - Implication for the Origin of Kuroko and Epithermal Vein-Type Mineralizations and the Global Geochemical Cycle, Eslevier Science.

Course No. GLM403: GEOLOGICAL FIELD TRAINING **Credit: 5**

Course No. GLM404: Practicals (connected with GLM401) **Credit: 2**

Megascopic and microscopic study of cores; Preparation of geological maps, sections and derivation of geological history in relation to petroleum prospects; Calculation of oil reserves; Exercises on maturation studies; Petrographic characterization of petroleum source rocks; Study of seismic maps; Preparation of SP and resistivity logs for hydrocarbon reservoirs.

Course No. GLM405: Practicals (connected with GLM402) **Credit: 2**

Rock analyses (rapid method of silicate analysis) and FeO determination by titration method; Determination of loss on ignition (LOI) of rock samples; Presentation of analytical data; Preparation of classificatory and variation diagrams and their interpretation; plotting of REE data and their interpretation; Calculation of weathering indices in soil and sediments.

Course No: GLM406: MINERAL EXPLORATION AND MINERAL ECONOMICS **Credit: 3**

Mineral Exploration

Unit-1
Selection of minerals for exploration; Role of GIS and remote sensing in mineral exploration; RP, PL and ML stages of mineral exploration in India; Criteria and guidelines for search of minerals; Field observations and field equipments and geological modeling for mineral exploration.

Unit-2
Geochemical exploration, mobility of elements and their primary and secondary dispersion; Geochemical approaches, mapping and sample material; Introduction to geo-botanical exploration methods; Use of geostatistics in exploration.

Unit-3
Objectives of drilling, types of drilling for exploration and their advantages; Concept of slice plan/bench plan and calculation of geological resource and mineable ore reserves; Concept of atomic energy; Mode of occurrence and exploration of atomic minerals.

Mineral Economics

Unit-4
Mineral economics and its concepts; Tenor, grade and specification; Strategic, critical and essential minerals; National mineral policy; United Nations Framework Classification (UNFC).

Books Recommended:
Arogyaswami, R.P.N. (1996): Courses in Mining Geology, Oxford and IBH Publ.
Bagchi, T.C., Sengupta, D.K., Rao, S.V.L.N. (1979): Elements of Prospecting and Exploration, Kalyani Publ.
Banerjee , P.K. and Ghosh, S. (1997): Elements of Prospecting for Non-fuel Mineral deposits, Allied Publ.
Chaussier, Jean – Bernard and Morer, J. (1987): Mineral Prospecting Manual., North Oxford Academic.
Dhanraju, R. (2005): Radioactive Minerals, Geol. Soc. India, Bangalore.
Mineral Concession Rules 1960 (2005), IBM, Nagpur.
Rajendran, S. (2007): Mineral Exploration: Recent Strategies.
Sinha, R.K. and Sharma, N.L. (1976): Mineral economics, Oxford and IBH Publ.

Course No: GLM407: BASIN ANALYSIS **Credit: 3**

Unit –1
Concept of basin analysis; Tectonic classification and geothermal evolution of sedimentary basins; Allogenic and autogenic controls on sedimentation.

Unit-2
Sedimentary facies and facies models with Indian analogues; Paleocurrent analysis and sediment dispersal patterns; Quaternary Sedimentology.

Unit-3
Processes and characteristics of depositional environments such as fluvial, estuarine, deltaic, lagoonal, barrier beach, tidal flats and deep-sea environments.

Unit-4
Concept of sequence stratigraphy, regional unconformities, systems tracts and parasequences.

Books Recommended:

Allen P. A. and J.R.L. Allen (2005): Basin Analysis: Principles and Application, Blackwell Publ.
Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag.
Perry, C.T. and Taylor, K.G. (2006): Envoronmental Sedimentology, Blackwell Publ., U.K.
Reading, H.G. (1996): Sedimentary Environments and facies, Blackwell Scientific Publ.
Reineck, H.E. and Singh, I.B. (1978): Depositional Sedimentary Environments, Springer-Verlag.

Course No. GLM408: APPLICATIVE PALEOBIOLOGY **Credit: 3**

Unit-1

Species concepts; Origin and diversity of life; Changes of ecosystems and habitat through time.

Unit- 2

Paleobiogeography; Aims, methodologies and theories; Numerical paleobiology; Cladestic and phylogenetic biogeography.

Unit- 3

Precambrian and Phanerozoic biogeography; Evolution of earth and its biota.

Unit- 4

Paleoecology — approaches, concepts and applications; Taphonomy — principles and practices; Fossil assemblages; Concept of time averaging; Shell concentration and stratigraphy of shell concentration.

Books Recommended:

Allison, P.A. and Briggs, D.E.G. (1991): Taphonomy. Releasing the data locked in the fossils record, Plenum Press.
Dord, J.R. and Stanta, R.J. (1981): Palaeoecology concepts and applications, John Wiley and Sons.
Patnaik, R. (2003): Reconstruction of Upper Siwalik palaeoecology and palaeoclimatology using microfossil palaeocommunities, Palaeogeography, Palaeoclimatology, Palaeoecology, Vo. 197.

Course No. GLM409: Practicals (connected with GLM406) **Credit: 2**

Mineral Exploration
Marking of different benches and stripping boundary on cross section; Calculation of ore grade, total geological resource and mineable reserves, total waste (inside, stripping and OB); Concept of ore dilution; Interpretation of remote sensing data for mineral exploration.

Mineral Economics
Preparation of mineral maps of India; Graphical representation of production, export and import of important minerals.

Course No. GLM410: Practicals (connected with GLM407) **Credit: 2**

Paleocurrent analysis; Preparation of facies maps and facies diagrams; Study of vertical profile sections of some selected sedimentary environments; Study of significant system tracts.

Course No. GLM411: Practicals (connected with GLM408) **Credit: 2**

Exercises on paleobiogeography, paleoecology and taphonomy.

SEMESTER - V

Course No: GLM501: MARINE GEOLOGY **Credit: 3**

Unit-1

History of development of marine geology; Origin of ocean basins; A brief account of tectonic history of the oceans; Oceanic crust; Deep ocean-floor topography; Morphology of ocean margins.

Unit-2

Marine sediments, sources and composition, sediment types and distribution; Oceanic sediments and microfossils; Deep sea sediments and their relation to oceanic processes such as productivity, solution and dilution; Sedimentation rates; Calcite and aragonite compensation depth.

Unit-3

Oceanic circulation - Surface, intermediate and deep ocean circulation; Forces that produce and effect circulation patterns in world oceans; Important phenomena associated with surface circulation; Formation and movement of deep and bottom waters.

Unit-4

Methods and instruments for exploring the ocean floor; Deep Sea Drilling Project (DSDP), Ocean Drilling Programme (ODP) and Joint Global Flux Studies (JGOFS) and their major accomplishments. Integrated Ocean Drilling Programme (IODP) and its aims and objectives; Sediment distribution in time and space as related to tectonic models; Marine stratigraphy, correlation and chronology; Deep sea hiatuses and their causes; Approaches to paleoceanographic and paleoclimatic reconstructions; Paleoceanographic changes in relation to earth system history including impact of the oceans on climate change; Evolution of oceans through the Cenozoic; Ocean gateways and their role in controlling global climates; Sea level changes during Quaternary with special reference to India; Reconstructing Quaternary climatic and oceanographic history on shorter time scales using marine records; Mineral resources of the ocean including polymetallic nodules; Hydrocarbons beneath the sea floor; Marine gas hydrates and their economic potential; Marine pollution and interpreting marine pollution with the help of microfossils.

Books Recommended:

Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford Univ. Press, New York.
Kennett, J.P. (1982): Laboratory Excercises in Oceanography Marine Geology, Prentice Hall,.
Seibold, E. and Berger, W.H. (1982): The Sea Floor, Springer-Verlag.

Course No: GLM502: ENVIRONMENTAL GEOLOGY AND NATURAL HAZARDS **Credit: 3**

Unit- 1

Components of environmental geology; Time scales of global changes in the ecosystem and climate; Major icehouse and greenhouse periods; Impact of oceanic and atmospheric circulation on climate and rain fall; Methodologies for estimation of present and past atmospheric carbon-dioxides; CO_2 increase and global warming in the present and past atmospheres.

Unit -2

Physical, chemical and biological domains of environment; Air, water and noise pollution, their causes and remedial measures**;** Surface weathering, development of soil and soil pollution; Pollution in the mining areas.

Unit-3

Distribution, magnitude and intensity of earthquakes; Seismic hazard zones; Neotectonics in seismic hazard assessment; Landslide, floods and volcanic hazards their causes and control; Coastal erosion, its causes and control.

Unit-4

Problems of urbanization, human population and their impact on environment; Alternative sources of energy; Waste disposal and related problems; Environmental legislations.

Books Recommended:

Bell, F.G. (1999): Geological Hazards, Routledge, London.

Bryant, E. (1985): Natural Hazards, Cambridge Univ. Press.
Keller, E.A. (1978): Environmental Geology, Bell and Howell, USA.
Lal, D. S. (2007): Climatology, Sharda Pustak Bhawan, Allahabad.
Patwardhan, A.M. (1999): The Dynamic Earth System, Prentice Hall.
Smith, K. (1992): Environmental Hazards, Routledge, London.
Subramaniam, V. (2001): Textbook in Environmental Science, Narosa International.
Valdiya, K.S. (1987): Environmental Geology – Indian Context, Tata McGraw Hill.

Course No: GLM503: ELEMENTS OF MINING, ORE DRESSING AND SURVEYING Credit: 3

Elements of Mining

Unit-1
Classification of mining methods, placer mining methods, open pit methods, underground mining methods, coal mining methods and ocean bottom mining methods, their advantages and disadvantages; Ventilation in underground mining; Purpose, types and arrangements of ventilation in underground mining; Mining hazards and safety measures.

Ore Dressing

Unit-2
Ore dressing and its importance, low grade ores and their beneficiation; ore microscopy and its contribution to ore dressing techniques; Mineral properties and their consideration in ore dressing techniques.

Unit-3
Basic ore dressing operations viz. crushing, grinding, sizing, screening and classification; Concentration processes; Magnetic and electrostatic separation, gravity concentration; Froth Floatation, amalgamation and agglomeration.

Surveying

Unit-4
Surveying - its uses and importance in Geology, common methods of surveying, chain surveying , prismatic compass, plane table, theodolite surveying; Concept of Global Positioning System (GPS).

Books Recommended:
Arogyaswami, R.P.N. (1996): Courses in Mining Geology, IV Ed. Oxford IBH.
Clark, G.B. (1967): Elements of Mining, (3rd Ed.), John Wiley.
Mookherjee, A. (2000): Ore Genesis-A Holistic Approach, Allied Publisher.
Roy Chowdhary, K.P. (1987): Surveying (Plane and Geodetic), Oxford and IBH Publ.
Shahani, P.B. (1978): Text book of Surveying Vol. 1, Oxford and IBH Publ.

Course No: GLM504: ENGINEERING GEOLOGY AND GEOPHYSICAL EXPLORATION Credit: 3

Unit-1
Role of engineering geology in civil construction and mining industry; Various stages of engineering geological investigations for civil engineering projects; Engineering properties of rocks, rock discontinuities, physical characters of building stones, concrete and other aggregates; Influence of geological structures (fold, fault and joint) on different civil engineering constructions; Mass movements – causes of landslides and their remedial measures.

Unit-2
Different types of dams and geotechnical investigation for dam and reservoir site; Geotechnical evaluation of tunnel alignment, methods of tunneling, classification of ground for tunneling purposes and various types of support system; Geological considerations involved in the construction of roads, railways and bridges; Earthquake resistance (aseismic) design of building and influence of geological condition on foundation; Shoreline engineering geology; Improvement of sites for engineering projects.

Unit- 3

Gravity methods - general principles (Newton's law, Gauss's law), gravity field of the earth, instruments; Gravity surveying, rock densities, gravity data reduction, interpretation of gravity data; Magnetic methods - general principles, earth's magnetic field, field instruments, rock magnetism; Surveying, airborne magnetic, interpretation of anomalies and potential field data (magnetic); Electrical methods - general principles, introduction to resistivity, self potential methods and induced potential; Resistivity surveying and resistivity data interpretation.

Unit – 4

Seismic Methods - general principles of seismic wave propagation, field procedures, equipment, seismic velocities, Snell's law, basic travel time relationships; General principles of seismic reflection and diffraction, seismic processing, seismic reflection interpretation; Geophysical well-logging - general principles and introduction to well logging.

Books Recommended:

Dobrin, M. B.; Savit, C. H. (1988): Introduction to Geophysical Prospecting, McGraw-Hill.
Keary, P., Brooks, M. and Hill, I. (2002): An introduction to geophysical exploration, (3rd Ed.), Blackwell.
Krynine, D.H. and Judd, W.R. (1998): Principles of Engineering Geology, CBS Publ..
Rider, M. H. (1986): Whittles Publishing, Caithness. The Geological Interpretation of Well Logs, (Rev. Ed.).
Robert, D. (1985): Encyclopedia of Well Logging.
Schultz, J.R. and Cleaves, A.B. (1951): Geology in Engineering, John Willey and Sons, New York.
Singh, P. (1994): Engineering and General Geology, S.K. Kataria and Sons, Delhi.
Telford, W.M., L.P. Geldart, R.E. Sherrif and D.A. Keys (1976): Applied Geophysics, Cambridge Univ. Press.

Course No. GLM505: Practicals (connected with GLM501) **Credit: 2**

Study of topographic features of ocean floor; Preparation of bathymetry maps; Study of subsurface geological conditions and structures using seismic depth sections of selected oceanic regions; Evolution of ocean circulation system during the Cenozoic; Estimation of sedimentation rates, exercises on identification of condensed zones, deep sea hiatuses in deep sea sedimentary sections; Determination of physical and textural properties of marine sediments.

Course No. GLM506: Practicals (connected with GLM502) **Credit: 2**

Preparation of seismic zonation maps of India and world; Demarcation of landslide prone areas in the Himalaya; Demarcation of flood prone areas in the outline map of India; Preparation of volcanic hazard zonation map; Presentation of chemical analysis data and plotting chemical classification diagrams; Preparation of oceanic and atmospheric circulation maps.

Course No. GLM507: Practicals (connected with GLM503) **Credit: 2**

Elements of Mining

Study of various methods of metal and local mining and their diagrammatic representation; Exercises on mine sampling and determination of tenor, cut-off grades, ore reserves, etc.

Ore Dressing

Study of flow sheets of important metallic and non-metallic ores and minerals with particular reference to Indian ores and minerals.

Surveying

Survey of a plot of land by means of common methods of surveying using different instruments: chain, prismatic compass, plane table, dumpy level, theodolite and GPS.

Course No. GLM508: Practicals (connected with GLM504) **Credit: 2**

Study of properties of rocks with reference to their use in engineering projects; Study of models and maps of important engineering structures such as tunnels and dams; Interpretation of geological maps for landslide problems.

Course No. GLM509: APPLICATIVE PALEOBOTANY AND PALYNOLOGY Credit: 3

Paleobotany

Unit-1
Introduction and approach to paleobotany; occurrence of plant fossils, their collection and preparation techniques; Principles of nomenclature (concept of genera and form genera); A brief idea about morphology of different plant parts; Evolutionary trend in angiosperms plants; A brief idea about Indian pre-Gondwana; Gondwana and Paleogene flora.

Unit-2
Application of paleobotany in assessing paleoclimate and paleoenvironment; Dendrochronology and its application; Phytoliths and their application in understanding paleoecology.

Palynology

Unit-3
Definition and scope of palynology, techniques in palynology; Introductory taxonomic classification of spores, pollen, dinoflagellates and acritarchs; Basics of spores/pollen biology and morphology; Pollen evolution, gymnosperm and angiosperm pollen through time; Production, dispersal and sedimentation of palynomorphs.

Unit-4
Holocene palynology and its application; Application of palynology in geochronology, paleoclimate and paleoenvironment interpretation; Significance of palynology in source rock evaluation and organic matter maturation; Fluorescence palynology and its application.

Books Recommended:
Alfred Traverse (1988): Paleopalynology, Unwin Hyman, USA.
Bergland, B.E. (1986): Handbook of Holocene paleoecology and paleohydrology, John Wiley, New York.
Jones, T.P. and Rowe, T.P. (1999): Fossil Plants and Spores Modern Techniques, Geological Soc. of London.
Pipero, Dologes, R. (1988): Phytolith analysis: an Archaeobiological and Geological perspective, Academic Press.
Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
Seaward, A.C. (1991): Plant fossils, Today's and Tomorrow, New Delhi.
Shipad N. Agashe (1995): Paleobotany, Oxford and IBH Publ., New Delhi.
Stewart, Wilson N. and Rothwell Gar W. (1993): Paleobotany and the Evolution of Plants, Cambridge Univ. Press.

Course No. GLM510: APPLIED VERTEBRATE PALEONTOLOGY Credit: 3

Unit-1
Origin of vertebrates, general characteristics of vertebrates, vertebrate skeleton, division and components of graniate skeleton; Classification of vertebrates, jawless vertebrates, origin of jaws; Pisces – placodermi, chondrichthyes, osteichthyes; parts of pisces preserved as fossils.

Unit-2
Amphibia - Labyrinthodont and their trends in evolution; Frogs and toads; Reptilia, marine reptiles, flying reptiles, mammal like reptiles; Dinosaurs and their causes of extinction; Aves – Archaeopteryx.

Unit-3
Mammalia - Origin and evolution of the mammals, mammalian characters, classification of mammals; Gondwana vertebrates; Siwalik mammals; Vertebrate life through ages; Evolutionary changes in Equidae, Proboscidae; Evolution of Homo, phases and culture chronology.

Unit-4
Placental mammals - basic characters, tooth morphology and classification; Age of mammals; Microvertebrates - collection, maceration, and their identification; Rodents - characters, classification and evolution.

Books Recommended:
Benton, M.J. (1990): Vertebrate Paleontology. Unwin Hyman, Lindon.

Colbert, E.H. (1984): Evolution of Vertebrates. Willey Eeastern Ltd.
Harris, J.M. and Leakey, M.G.(2003): Geology and Vertebrate Paleontology of Early Pliocene Site of Kanapoi, N. Kenya, Vol. 498, Natural History Museum, Lons Angeles.
Olson, E.G. (1971): Vertebrate Palaeozoology, Wiley, New York.
Romer, A.S. (1966): Vertebrate Paleontology (3rd Edn.) Chicago University Press.
Swnnerton, H.H. (1950): An outline of paleontology, Edward Arnold and Co.

Course No. GLM511: GEMOLOGY **Credit: 3**

Unit-1
Gem and gemstones; General characteristics and chemical composition of gemstones; Application of gemstones; Technical application, application as jewels; Physical characteristics - form, cleavage, fracture, hardness, specific gravity and tenacity.

Unit-2
Optical characteristics - colour, luster, play of colour, refractive index, reflectivity, diaphaneity pleochroism, dispersion; Application of ultraviolet rays, x-rays and infra red rays in gem identification; Electrical thermal and magnetic characters of gems; Classification of gemstones.

Unit-3
Systematic description, genesis, mode of occurrence, distribution in India and also important world occurrences of important precious and semi-precious stones.

Unit-4
Synthetic gemstones - methods of synthesis, and its characteristics and identification; Gem enhancement methods and their identification; Colourless/coloured impregnation, head treatment, coating, irradiation, diffusion, treatment, etc.

Books Recommended:
Brocardo, G. (1981): Minerals and Gemstone- An identification guide, David and Charles, London.
Bruton Eric F.G.A. (1970): Diamonds, Chilton Book Company.
Max Bauer (1968): Precious Stones, Vol. I and II, Dover, New York.
Orlov Yu L (1973): The Mineralogy of the Diamond, John Wiley.
Rajendran S. (2007): Mineral Exploration: Recent Strategies.
Vilson, M. (1967): Gems, Heinemann, London.

Course No. GLM512: COMPUTER APPLICATION AND INSTRUMENTATION IN GEOLOGY
Credit: 3

Computer Application

Unit-1
Use of computers and software as tools in the areas of geological problem-solving, report-writing, and presentations; Windows-based software applications, including word-processing, spreadsheets.

Unit-2
Graphing, image manipulation, drawing, presentations (MS-Excel, Power Point, Adobe Illustrator, CorelDraw, Photoshop).

Instrumental techniques in Geosciences

Unit-3
Role and importance of instrumentation techniques in Geology; Brief introduction to the instrumental techniques with emphasis on their applicational aspects.

Unit-4
X-ray diffractometer, image analyzer, electron probe micro analyzer, scanning electron microscope, transmission electron microscope, isodynamic separator, ultra violet lamp, infrared spectrometry, atomic absorption spectrometer, x-ray fluorescence spectrometer, inductively coupled plasma analyzer, mass spectrometer and various mineral dressing and geophysical instruments.

No Textbook - only handouts and web pages

Course No. GLM513: SOIL GEOLOGY **Credit: 3**

Unit-1
Concept of soil, components of soil, soil profile; Process of soil formation, pedogenic processes; Classification of soil, mineral and chemical composition of soils, mineral stability during weathering; Soil organic matter form and function; A brief introduction to methods of soil conservation.

Unit-2
Fabric analysis - size and shape, concepts of size and shape, grade scale, methods of analysis, presentation of data, analysis and field grading; Concepts of structure fabric: Soil fabric, soil structure, soil texture and field grading units; Peds and pedalilty, size and shape of peds, pedality, primary, secondary and tertiary structures and their interpretation; Voids - concepts, size, shape, arrangement and morphological classification.

Unit-3
Paleosols - field recognition, description, origin and causes; Paleosol in stratigraphic records; Significance of paleosol study; Paleosols and human evolution.

Unit-4
Calcrete - definition, classification, calcrete formation, pedogenic calcrete soil profile, macro features in calcretes, micromorphology (petrography), calcretes from Quaternary and ancient sedimentary sequences; significance of calcretes; Laterite - characteristics, genesis, Indian occurrences.

Books Recommended:

Boul, S.W., Hole, F.D., McCraken, R.J. and South, R.J. (1997): Soil Genesis and classification. 4th Edition, State University Press.
Braddy, N.C. (2002): Nature and Properties of Soils.
Govinda Rajan, S.V. and Gopala Rao, K. H.G. (1979): Studies of Soils of India.
Sposito, Garrison. (1989): The Chemistry of Soils, Oxford Univ. Press.
Terzaghi, K. and Pock, R.G. 1996): Soil Mechanics in Engineering (3rd Ed.), John Wiley.
Wright; V. Paul (1992): Paleosols: their recognition and interpretation, Blackwell Scientific Publ.
Wright, V. Paul and Tucker, M.E. (1991): Calcretes. Blackwell Scientific Publ..

Course No. GLM514: SEQUENCE STRATIGRAPHY **Credit: 3**

Unit -1
Sequence stratigraphy, its concept and evolution; Order and duration of sequences; Application and significance of sequence stratigraphy.

Unit - 2
Fundamentals of sequence stratigraphy, depositional sequence, sequence architecture, types and boundaries, condensation and starvation; Conformity and types of sequence unconformities; Flooding surface, maximum flooding surface, marine flooding surface; Bed, bedset, parasequence, parasequence boundary, parasequence set; System tracts - lowstand system tract, transgressive system tract, transgressive surface and highstand system tract, overlap, offlap, toplap and onlap, aggradation, progradation, retrogradation, transgression and regression; Eustatic sea level changes, sediment supply, basin subsidence rate, and accommodation.

Unit - 3
Outcrop, subsurface and offshore sequence stratigraphy and their integration; Seismic stratigraphy; Sequence stratigraphy in well sections and application of well logs.

Unit – 4
Sequence stratigraphic approach in basin analysis with Indian examples.

Books Recommended:

Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall.

Coe, Angela, Dan Bosence, Kevin Church, Steve Flint, John Howell and Chris Wilson (2002): The Sedimentary Record of Sea Level Change , Cambridge Univ. Press.
Emery, D, (1996): Sequence Stratigraphy, Blachwell Scientific Publ.
Miall, A.D. (1997): The Geology of Stratigraphic Sequence, Springer-Verlag.
Reineck, H.E., and Singh, I.B. (1980): Depositional Sedimentary Environments, Springer-Verlag.
Vail, P.R., Mitchum, R. M., Todd, R. G., Widmier, J. M., Thompson, S., Sangree, J.B., Bubb, J.N.and Hatlelid, W.G. (1977): Seismic stratigraphy and global changes of sea level: American Association of petroleum Geologists, Vol.26.

See web pages

Course No. GLM515: PLANETARY GEOSCIENCE **Credit : 3**

Unit-1
Origin of solar system; Geology of solar system and abundances of the elements; Importance of planetary geosciences.

Unit-2
Meteoritic impacts and terrestrial catastrophes; Shock metamorphism; Definition, falls, finds, and parent bodies of meteorites.

Unit – 3
Classification of meteorites, chondrites, achondrites, iron and stony-iron meteorites.

Unit – 4
Classification, petrology, chemistry and genesis of chondirtes and achondrites (asteroidal, lunar and martian); Case study of important Indian meteorites; Indian space mission – Chandrayan.

Books Recommended:
Davis, A. M. (2005): Meteorites, Comets, and Planets, Elsevier.
Harry, Y. Mc Sween, Jr. (1999): Meteorites and Their Parent Planets (Second edition), Cambridge Univ. Press.
Hutchinson, R. (2004): Meteorites A petrologic, Chemical and Isotopic synthesis, Cambridge Univ. Press.
McBride, N. and Gilmour, I (2003): An Introduction to the Solar System, Cambridge Univ. Press.
Norton, O. R. (2002): The Cambridge Encyclopedia of Meteorites, Cambridge Univ. Press.
Rollinson, H. (2007): Early Earth System A Geochemical Approach, Blackwell Publ.
Zanda, B. and Rotaru, M. (2001): Meteorites Their Impact on Science and History, Cambridge Univ.Press.

Course No. GLM516: PALEOBIOGEOGRAPHY AND PLATE-TECTONICS **Credit: 3**

Unit-1
Paleobiogeography, its methodologies and applications; Paleobiogeographic principles and practices; Origin and diversity of life; Species concepts.

Unit-2
Paleobiogeographic analyses, paleobiogeographic units - realms and provinces, similarity coefficients; Role of tectonics on Paleobiogeography.

Unit-3
Distribution, migration and dispersal of organisms; Application to Paleobiogeography, plate-tectonics – examples from Indian Phanerozoic.

Unit-4
Case sheets from Indian Phanerozoic geological record.

Books Recommended:
Bird, J.M. (1980): Plate Tectonics, American Geophysical Union, Washington D.C.
Briggs, J.C. (1987): Biogeography and Plate Tectonics, Elsevier.
Lieberman, B. L.(2000): Paleobiogeography: using fossils to study Global Change, Plate Tectonics and Evolution, Plenum Publ., New York.

Jacquelyne Kious, J. and Tilling, R.I. (2007): This Dynamic Earth: The story of Plate Tectonics, USGS Information Services.

SEMESTER - VI

Course No. GLM601: Project Oriented Dissertation **Credit: 22**

It envisages geological field work (7 credits), periodic presentations (5 credits) and submission of thesis and final presentation of 10 credits (8 and 2 credits respectively for thesis and presentation). The area of Dissertation shall be assigned to the students at the end of Semester - IV based on the merit of the students and expertise available in the Department. The project oriented dissertation thesis must be submitted by the end of Semester – VI through detailed field work, laboratory investigations, periodic seminar presentation followed by final presentation before the faculty members and the board of examiners for the purpose of evaluation.

M.Sc. (Tech.) GEOPHYSICS
Department of Geophysics
Banaras Hindu University

M.Sc. (Tech.) Geophysics

Demesterwise distribution of Courses and Credits

Semester- I

Course Code	Title	Credits
GPM 101	Elements of Geology	4
GPM 102	General Meteorology	4
GPM 103	Numerical Methods and Computer Programming	4
GPM 104	Practical based on course GPM101	2
GPM 105	Practical based on course GPM102	2
GPM 106	Practical based on Computer Programming	2
GPM 107	Excursion & Tour Report	2
GPM108M #	Minor Elective: Fundamentals of Meteorology *(for students of other PG programmers)* Minor Elective *(for Geophysics students)*	3
	Total	**23**

Semester- II

Course Code	Title	Credits
GPM 201	Geohydrology	4
GPM 202	Geoexploration & Surveying	4
GPM 203	Stratigraphy, Economic and Petroleum Geology	4
GPM 204	Solid Earth Geophysics	4
GPM 205	Practical based on course GPM201	2
GPM 206	Practical based on course GPM202	2
GPM 207	Practical based on course GPM203	2
GPM208M #	Minor Elective: General Geophysics (for students of other PG programmers) Minor Elective (for Geophysics students)	3
	Total	**25**

Semester- III

Course Code	Title	Credits
GPM 301	Seismology	4
Any one combinations of two courses of Group A (*Exploration Geophysics): (GPM302A-GPM306A) or Group B (Meteorology): (GPM302B - GPM306B)*		
GPM 302A GPM 302B	Geoelectrical Meteorology Agricultural Meteorology	4
GPM 303 A GPM 303B	Seismic Methods Climatology	4
GPM 304A GPM 304B	Practical based on course GPM302A Practical based on course GPM302B	2
GPM 305A GPM 305B	Practical based on course GPM303A Practical based on course GPM303B	2
GPM 306A GPM 306B	Geophysical Field Training (GPM306A/GPM306B)	2
GPM 307	Practical based on course GPM301	2
GPM 308M #	Minor Elective: Fundamentals of Geoexploration *(for students of other PG programmers)* Minor Elective *(for Geophysics students)*	3
	Total	**23**

Semester- IV

Course Code	Title	Credits
GPM401	Mathematical Methods in Geophysics	4
GPM402	Petroleum Geophysics & Stratigraphy	4
GPM403	Instrumentation & Signal Processing	3
Any one of the corresponding combination of four courses of Group A *(GPM404A-GPM 407A) or Group B (GPM404B-GPM 407B)*		

GPM404A GPM404B	Gravity and Magnetic Methods Dynamic Meteorology	4
GPM405A GPM405B	Well Logging & reservoir Geophysics Physical Meteorology	4
GPM 406A GPM 406B	Practical based on course GPM404A Practical based on course GPM404B	2
GPM 407A GPM 407B	Practical based on course GPM405A Practical based on course GPM405B	2
	Total	**23**

Semester- V

Course Code	**Title**	**Credits**
GPM501	Advanced Computer Programming	3
GPM502	Communication Theory	4
Any one of the corresponding combination of four courses of Group A *(GPM503A-GPM 506A) or Group B (GPM503B-GPM 506B)*		
GPM503A GPM503B	Geoelectromagnetic Methods Synoptic and Tropical Meteorology	4
GPM504A GPM504B	Digital Electronics & Microprocessor Advanced Dynamic Meteorology	4
GPM505A GPM505B	Practical based on course GPM503A Practical based on course GPM503B	2
GPM 506A GPM 506B	Practical based on course GPM504A Practical based on course GPM504B	2
GPM 507	Practical based on course GPM501	2
GPM 508	Practical on Geophysical Data Processing	2
	Total	**23**

Semester- VI

Course Code	**Title**	**Credits**
GPM601	Physical Oceanography and Marine Geophysics	4
GPM602 (P-Z)	One of the Elective courses (GPM602P to GPM602Z) (P) Advanced Hydrology ; (Q) Advanced Seismology ; ® Remote Sensing and GIS ; (S) Environmental Geophysics ; (T) Geomagnetism ; (U) Non-linear System in Geophysics ; (V) Geo tomography and Computer modeling ; (W) Modern Techniques in Seismic Interpretation and mitigation ; (X) Advanced Physical Meteorology ; (Y) Applied Meteorology ; (Z) Advanced Climatology.	4
GPM603	Seminar (in the respective specialization Groups)	2
GPM604A GPM604B	Comprehensive viva-voce (GPM604A/GPM604B)	3
GPM605A GPM605B	Project work/Dissertation (Corresponding specialization Group A/Group B)	8
	Total	**21**
	Grand Total	**138**

M.Sc. (Tech.) Geophysics students will opt 3 Minor Electives (3 credits each in semester I, II and III) offered by other PG Programmes of the Faculty.

NOTE:

1. Students of Semester – IV will initiate dissertation/ project work during summer vacation at laboratories outside Varanasi, if required.
2. Students of Semester- II will carry out summer Training at different laboratories outside Varanasi. if desired by the students
3. Students of Semester – III will carry out their Field Training during the Semester Break.
4. For dissertation work the co-supervisor(s) be allowed for the outside organization.

SEMESTER-I

GPM101: ELEMENTS OF GEOLGY **Credits: 4**

1. Physical and Structural Geology: Introduction to geology, scope, subdisciplines and relationships with other branches of science, weathering agents, landslides and volcanic activity, Representation of altitude, Dip and strike,outcrops, outlier and inlier, Folds, faults, unconformities, joints and their classification, criteria of their recognition, clinometer compass and its use.
2. Mineralogy: Mineral – its definition and mode of occurrence, physical properties of minerals like form, colour, lustre, streak, cleavage,fracture,hardness and specific gravity, Physical characters and chemical composition of the following rock forming minerals : Quartz, Orthoclase, Microcline, Plagioclase , Nepheline, Muscovite,Biotite, Augite, Hornblende, Olivine, Garnet, Epidote, Calcite and Beryl, graphite, tourmalilne, talc, Kaolinite, Kyanite and Corundum.
3. Perology : Rock- its definition, classification and distinguishing characteristics of Igneous, Sedimentary and Metamorphic rocks forms of Igneous rocks, elementary ideas regarding formation, texture and structure of Igneous, Sedimentary and Metamorphic rocks, brief petrographic description and occurrences of the following rocks: Granite, Syenite, Gabbro, Rhyolite, Dolerite, Basalt, Conglomerate, Breccia, Sandstone, Limestone, Shale, Gneiss, Schist, Quartzite and Marble, Formation of rocks in plate tectonic settings.

Suggested Books:

1. Berry & Mason : Mineralogy
2. Billings : Structural Geology
3. Mukherjee : A Text Book of Geology
4. Read & Rutley's : Elements of Mineralogy
5. Singh : Stuctural Geology: A Practical Approach
6. Smith : Minerals and Microscope
7. Tyrrell : Principles of Petrology

GPM102: GENERAL METEOROLOGY **Credits: 4**

1. Instrumentation: Surface, self recording and upper air meteorological instruments (mercury and aneroid barometer, barograph, air thermmeters,bimetallic thermograph, psychrometer, hair hygrograph, cup anemometer, Dines pressure tube anemograph, ordinary and recording rain gauges, nephoscope, sunshine recorder.
2. Composition and structure of the atmosphere.
3. Evaporation, condensation, fog, cloud and precipitation, thunderstorm, supercell and multi cell structure, tornado.
4. Thermodynamics: Thermodynamic principles, properties of dry and moist air, adiabatic processes, hydrostatic stability and instability, parcel method, tephigram.
5. Radiation: Solar and terrestrial radiation, laws of radiation, green house effect, Simpson”s method of computing long wave radiation flux, heat balance of the earth and its atmosphere.
6. Wind System: Geostrophic wind, gradient wind, thermal wind, cyclostrophic wind and inertial wind, land and sea breezes, mountain and valley winds.
7. Air masses, front, jet stream. Extra tropical and tropical cyclones and anticyclones, western disturbances.
8. General Circulation of the Atmosphere: N.E. And S.W. Monsoon, seasons.
9. Principles of weather forecasting.

Suggested Books:

1. Byers: General Meteorology IV edition
2. Cole : Introduction to Meteorology
3. Pettersen: Introduction to Meteorology
4. Banerjee & Upadhyay: Mausam Vigyan
5. Lutgens & Tarbuck: the atmosphere: An Introduction to Meteorology
6. Rama Sastry: Weather and Weather Forecasting
7. Das: the Monsoons
8. Wallace and Hobbs: Meteorology and Introductory Survey

GPM103: NUMERICAL METHODS AND COMPUTER PROGRAMMING Credits: 4

1. Numerical Methods: Solution of algebraic and transcendental equations, bisection and Newton-Raphson methods, solution of simultaneous linear equations, matrix inversion method, interpolation, Newton and Lagrange formula, numerical differentiation, numerical integration, Simpson, trapezoidal and Gaussian quadrature methods, least square curve fitting, straight line and polynomial fits, numerical solution of ordinary differential equation, Euler and Runga-Kutta methods, finite difference methods.
2. Computer Programming: Low level and high level languages, overview of compilers, interpreters and operating systems, problem solving on a computer, algorithms and flow charts integer and floating point arithmetic, Fortran preliminaries, constants, variables, data types and expressions, built in functions, executable and non-executable statements assignment, control and input /output statements, subroutines and functions, operations with files.

Suggested Books:

1. Sastry: Introductory Methods of Numerical Analysis
2. Jain, Iyengar & Jain: Numerical Methods for Scientific and Engineering Computation
3. Raja Raman: Numerical Analysis
4. Raja Raman: Fundamentals of Computers
5. Raja Raman: Fortran Programming
6. Ram Kumar: Programming with Fortran 77

GPM104: PRACTICAL BADED ON COURSE GPM101 Credits: 2

1. Clinometer compass and its use for determination of dip and strike of different beds.
2. Geological problems on slope, dip and thickness of the beds.
3. Drawing of geological sections of the given maps.
4. Study of the physical properties pf rock forming minerals (given in theory syllabus).
5. Megascopic study of rocks given in theory syllabus.

GPM105: PRACTICAL BADED ON COURSE GPM102 Credits: 2

1. Familiarization with meteorological instruments and record surface meteorological observations.
2. Study of surface weather and upper air codes.
3. Exercises in coding and decoding.
4. Exercises in plotting station models.

GPM106: PRACTICAL BADED ON COMPUTER PROGAMMING Credits: 2

To write and execute computer programs in FORTRAN language for the following problems:

1. Solution of transcendental or polynomial equation by Newton Raphson methods.
2. Numerical integration using Simpson/Gaussian quadrature method.
3. Solution of first order differential equation using Runga-Kutta method.
4. Linear curve fitting and calculation of linear correlation coefficients.
5. Matrix inversion and solution of simultaneous equations.
6. Numerical first order differentiation of a given.

GPM107: EXCURSION AND TOUR REPORT Credits: 2

During the first Semester, the students will be required to visit some geophysical establishments and laboratories in the country to acquaint themselves with various geophysical activities and submit the tour report to the tour In-charge. The visit may be arranged during the intra/inter Semester break.

GPM108M: FUNDAMENTALS OF METEORLOGY Credits: 3

1. Composition and structure of the atmosphere.
2. Evaporation, condensation, fog, cloud, precipitation and thunderstorm.
3. Thermodynamic: Thermodynamic principles, properties of dry and moist air, adiabatic processes, hydrostatic stability and instability, parcel method.

4. Radiation: Solar and terrestrial radiation, definitions, laws of radiation, albedo, green house effect.
5. Local winds: Land and sea breezes, mountain and valley winds, anabatic and katabatic winds, foehn or Chinook.
6. Condensation, precipitation, air masses, front, jet stream, extra-tropical and tropical cyclones, western disturbances, anticyclones, tornado.
7. General Circulation of the Atmosphere: N.E. And S.W. Monsoon, seasons, climate and weather.

Suggested Books:

1. Byers: General Meteorology IV edition
2. Cole: Introduction to Meteorology
3. Pettersen: Introduction to Meteorology
4. Banerjee & Upadhyay: Mausam Vigyan
5. Lutgens & Tarbuck: The Atmosphere: An Introduction to Meteorology
6. Das: The Monsoon

SEMESTER-II

GPM201: GEOHYDROLOGY Credits: 4

1. Hydrology cycle, origin of groundwater, subsurface distribution of water, springs.
2. Hydrology Properties of Water Bearing Materials: Porosity, void radio, permeability, transmissivity, storativity, specific yield, specific retention, diffusivity, laboratory methods of determination of permeability.
3. Mode of occurrence of groundwater , classification of rock with respect to their water bearing characteristics, aquifers, aquicludes, aquitards, classification of aquifers and groundwater provinces.
4. Movement of groundwater and aquifer performance tests, Darcy's law and its range of validity, theory of groundwater flow under steady and unsteady conditions, determination of permeability, transmissivity and storativity by discharging methods.
5. Precipitation, evaporation, evapotranspiration, seepage, infiltration and runoff.
6. Groundwater exploration, surface geological and geophysical methods of exploration, and subsurface geophysical methods.
7. Hydro-geochemistry: Physical and Chemical characteristics of groundwater, classification of groundwater in respect to domestic, irrigation and industrial use, pollution of groundwater.
8. Ground Water Exploration and Management: Natural and artificial recharge of groundwater, water balance, analysis of hydrograph, conjunctive and consumptive use of groundwater.

Suggested Books:

1. Worcester: A Text Book of Geomorphology
2. Todd: Groundwater Hydrology
3. Ward: Principles of Hydrology
4. Chow: Handbook of Applied Hydrology
5. Health & Trainer: Introduction to Groundwater Hydrology
6. Singh: Elements of Hydrology
7. Raghunath: Introduction to Hydrology
8. Tolman: Hydrology
9. Karanth: Development, Assessment and Management of Water Resources

GPM202: GEOEXPLORATION AND SURVEYING Credits: 4

1. Basic principles of geophysical exploration.
2. Physical properties of minerals and rocks.
3. Gravity Method: Stable and unstable gravimeters, Worden, Lacoste and Romberg, Hartley Askania and Gulf gravimeters, field procedure and reduction gravity data.
4. Magnetic Method: Fluxgate and Proton Precession magnetometers. Anomalies due to point pole and dipole, field practices and corrections.
5. Electrical Method: Elements of SP,IP and resistivity methods, Wenner and Schlumberger configurations. Methods of resistivity profiling and sounding, theory of images, Tagg's method of interpretation.

6. Seismic Method: Elementary principle of reflection and refraction methods, two layered reflection and refraction problems including inclined layer, fundamentals of conventional seismic instruments, fan shooting, profile shooting, continuous profiling and correlation methods of surveying.
7. Radiometric Method: Physical and geological principles of radiometric method, successive disintegrations equilibrium conditions, GM counter, scintillation counter and gamma ray spectrometer, radon measurements.
8. Basic principles of electromagnetic and GPR methods.

Suggested Books:

1. Dobrin & Savit: Introduction to Geophysical Prospecting
2. Parasnis: Principle of Applied Geophysics
3. Telford et al : Applied Geophysics
4. Sharma: Geophysical Prospecting for Geologists and Engineers
5. Israel & Krebs : Nuclear Radiation in Geophysics

GPM203: STRATIGRAPHY, ECONOMIC & PETROLEUM GEOLOGY Credits: 4

1. Stratigraphy: Principles of Stratigraphy, elements of stratigraphic classification; geological time scale. Basic concepts of sequence Stratigraphy and seismic stratigraphy Geophysical methods of stratigraphic correlation. Physical and structural divisions of Indian subcontinent and their characteristics. Classification, lithology and economic importance of the following: Dharwar supergroup of Karnataka, Cuddapah supergroup of Andhra Pradesh, Vindhyan Supergroup of Son valley, Gondwana Supergroup of peninsular India and Tertiary of Assam, Siwaliks of Himalaya.
2. Economic Geology: Definition of ore, ore mineral and gangue, Classification of ore deposits, Chemical composition, diagnostic characters, usages and distribution in India of the following metallic and non-metallic minerals: Haematite, magnetite, pyrolusite, psilomalane, chromite, ilmenite, wolframite, cassiterite, chalcopyrite, boronite, galena, sphelerite, pyrite, bauxite sulphur, graphite, gypsum, fluorite, barite, magnesite, dolomite, apatite, calcite, kyanite, sillimanite, beryl, muscovite, kaolinite, halite and talc.
3. Petroleum Geology: Origin of petroleum; source rocks; reservoir rocks; reservoir pore spaces; reservoir traps. Migration and accumulation of oil and gas. Geological modelling in petroleum exploration, Brief geological account of oil and gas fields in India: Assam, Gujarat, Tamil Nadu and Bombay Offshore.

Suggested Books:

1. Jensen and Bateman: Economic Geology
2. Krishna Swami: India's Mineral Resources
3. Sharma & Ram: Introduction to India's Economic Minerals
4. Levorsen: Geology of Petroleum
5. Evans & Mathur: Oil in India
6. Krishman: Geology of India and Burma
7. Wadia: Geology of India.
8. Ravindra Kumar: Historical geology and stratigraphy of India
9. U. Prasad: Economic geology.

GPM204: SOLID EARTH GEOPHYSICS Credits: 4

1. History of development and scope of geophysics, monistic and dualistic hypotheses for the origin of solar system, Kepler's law of planetary motion, planet and satellites of the system and their characteristics, shape and size of the earth, international gravity formula and rotation of the earth. Concept of isostasy, Airy, Heiskanan and Pratt-Hayford hypotheses.
2. Internal constitution of the earth, characteristics of lithosphere, and asthenosphere, causes of geodynamical process, geodynamic models, continental drift. Ocean floor spreading, plate tectonics and its geological implications, new global tectonics and plate margin process, geomagnetic time scale, Benioff zones, oceanic ridges, evolution of the triple junction, trenches and island arcs, hot spots, geodynamics of Indian subcontinents and formation of Himalayas, 90^0 E ridge.
3. Origin of geomagnetic field, secular variations and westward drift, geomagnetic storms, Earth's current, sun spot, solar flares, lunar and solar variations, Palaeomagnetic studies of rock samples and their applications in geophysics, polar wandering, reversals of geomagnetic field.

4. Importance of heat flow, thermal history of the earth, sources of heat generation and temperature distribution inside the earth, Jacob's hypothesis for liquid nature of the outer core. Radiometric dating principles and ages of rocks and the earth.

Suggested Books:

1. Howell : Introduction to Geophysics
2. Stacey: Physics of the Earth
3. Gubbins: Seismology and Plate Tectonics
4. Condie: Plate Tectonics and Crustal Evolution
5. Lowrie: Fundamentals of Geophysics
6. Bird & Lacks: Plate Tectonics
7. Chapman: Earth's Magnetism
8. Jacobs: Core and Geomagnetism

GPM205: PRACTICAL BASED ON COURSE GPM201 **Credits: 2**

1. Determination of average rainfall.
2. Determination of evaporation and evapotranspiration.
3. Determination of storativity coefficient and transmissivity.
4. Determination of porosity and permeability.

GPM206: PRACTICAL BASED ON COURSE GPM202 **Credits: 2**

GEOEXPLORATION

1. Handing of gravimeter and magnetometer.
2. Interpretation of resistivity sounding data by Tagg's method.
3. Determination of velocities and depth of the interface by refraction method.

SURVEYING

1. Handling of surveying instruments- theodolite, dumpy-level, microptic alidade, electronic distance measuring devices, GPS.
2. Preparation of site map with the help of plane table.
3. Determination of height using theodolite.

GPM207: PRACTICAL BASED ON COURSE GPM203 **Credits: 2**

1. Preparation of lithostratigraphic maps of India showing distribution of Dharwar, Cuddapah, Vindhyan and Gondwana Super groups.
2. Study of about 15 rock specimens from the important stratigraphic horizons of India.
3. Study of mega-scopic characters of about 25 economic minerals.
4. Distribution of important mineral deposits of India.
5. Exercises on accumulation of oil and gas in different types of traps.
6. Distribution of important petroliferous basins of India.

GPM208M: GENERAL GEOPHYSICS **Credits: 3**

1. History of development and scope of geophysics, monistic and dualistic hypotheses for the origin of solar system, Kepler's law of planetary motion, planet and satellites of the system and their characteristics, shape and size of the earth, international gravity formula and rotation of the earth. Concept of isostasy, Airy, Heiskanan and Pratt-Hayford hypotheses.
2. Internal constitution of the earth, continental drift, ocean floor spreading, plate tectonics and its geological implications, new global tectonics and plate margin process, oceanic ridges, trenches and island arcs, geodynamics of Indian subcontinents and formation of Himalayas.
3. Origin of geomagnetic field, polar wandering, secular variations and westward drift, geomagnetic storms, earth's current, sun spot, solar flares, lunar and solar variations, Fundamentals of palaeo-magnetic studies and palaeo-magnetism of rocks.

Suggested Books:

1. Howell: Introduction to Geophysics
2. Stacey: Physics of the Earth
3. Gubbins: Seismology and Plate Tectonics
4. Condie: Plate Tectonics and Crustal Evolution

5. Lowrie: Fundamentals of Geophysics
6. Bird & Lacks: Plate Tectonics
7. Chapman: Earth's Magnetism
8. Jacobs: Earth's Core and geomagnetism

SEMESTER-III

GPM301: SEISMOLOGY **Credits: 4**

1. Introduction to earthquake phenomena, concept of focus, focal depth, epicentre, great Indian earthquakes, intensity and magnitude scales and energy of earthquakes, foreshocks and aftershocks, elastic rebound theory, seismicity of India, Himalayas and global seismicity, seismic zonation, seismic micro-zonation, seismic zoning of India, induced seismicity, concept of inhomogeneity and anisotropy, types and causes of earthquakes.
2. Seismic ray theory for spherically stratified earth and velocity structure from travel time data, propagation and characteristics of body waves, surface waves, group and phase velocities, different phases of body waves and their applications, preparation of preliminary reports and identification of phases, determination of epicentre, focal depth and magnitudes, theory of elasticity, reflection of body waves, focal mechanism solutions and tectonic implications, earthquake generation models, hazard analysis, reflection of seismic waves from the free surface.
3. Principle of electromagnetic seismograph, displacement meters, velocity meter, accelerometer and strain meter seismographs, WWSSN stations, seismic arrays for detection of nuclear explosions, wideband seismometry, strong motion seismograph.

Suggested Books:

1. Richter: Elementary Seismology
2. Bullen & Bolt: An Introduction to the Theory of Seismology
3. Agrawal: Engineering Seismology
4. Gutenberg: Internal Constitution of the Earth
5. Rikitake: Earthquake Prediction
6. Bath: Introduction to Seismology
7. Slawomir & Andrezej: An introduction to Mining Seismology
8. Stein & Wysession: An Introduction to Seismology, Earthquakes and Earth structure

GPM302A: GEOELECTRICAL METHODS **Credits: 4**

1. General: Electrical properties of rocks & minerals and their determinations, fundamentals of direct current flow, relationship between point and line pole potential distribution.
2. Measuring System: Quantities measured in various electrical methods and description of the instruments used, discussion of various configurations used in electrical method and field procedure adopted.
3. D.C. Resistivity Methods: Potential distribution at the surface of horizontally stratified earth, Kernel function and its relation to the subsurface parameters, apparent resistivity function, computation of apparent resistivity model curves, principle of digital linear filtering.
4. Vertical Electrical Sounding: Interpretation of resistivity VES data, empirical methods for interpretation of resistivity sounding data, indirect interpretation techniques, auxiliary point method, partial curve matching, complete curve matching, direct interpretation techniques, automatic direct interpretation method, Dar Zarrouk parameters, inversion techniques in resistivity method of interpretation, computer-aided resistivity data interpretation (softwares), principles of equivalence, suppression and detectibility problems, effects of deviations from the fundamental assumptions, electrical resistivity imaging.
5. Electrical Profiling: Profiling near a vertical contact and thin vertical dykes and discussion of the expected apparent resistivity curves.
6. Self Potential Method: Mechanism of SP field techniques, field due to vertically polarized sphere and interpretation.
7. Induced Polarized Method: Mechanism of IP instruments and principles of measurements both in time and frequency domain, interpretation of IP.
8. Other methods: Principles, application and interpretation of potential drop ratio method, equipotential lines method and telluric current methods.

Suggested Books:

1. Bhattacharya & Patra: D.C. Geoelectric Sounding: Principles and Interpretation
2. Kuntez: Principles of Direct Current Resistivity Prospecting

3. Keller & Frischknecht: Electrical Methods in Geophysical Prospecting
4. Nostrand & Cook: Interpretation of Resistivity Data
5. Wait: Over-voltage Research and geophysical application
6. Koefoed: Geosounding Principe-I: Resistivity Sounding Measurements
7. Patra & Nath: Schlumberger Geoelectric Sounding in Ground Water
8. Ghosh: The Application of Linear Filter theory to the Direct Interpretation of Geoelectrical Resistivity Measurements

GPM302B: AGRICULTURAL METEOROLOGY **Credits: 4**

1. Meaning and scope of agricultural meteorology, Intent and extent of agricultural meteorology, plant physiology, long term and short term modifications of growth process, avoidable and unavoidable dangers.
2. Agrometeorological observations: Air, surface and soil temperature, air and soil humidity, wind, precipitation, sunshine, radiation intensity and microclimatic measurements.
3. Solar Radiation and Plants: Reflection, transmission and absorption, incoming, outgoing and net radiation, Spectral distribution of solar radiation and physiological response to plants, Light distribution in canopy, Phototropism and Photoperiodism: Meteorological factors in photosynthesis.
4. Environmental Temperature and Plants: Effect of low and high ambient temperature, growing degree days and other heat indices, soil temperature and factors affecting them, thermal properties of soil, Cardinal temperatures, soil moisture and its measurement, weekly water balance, water use and plant growth, evaporation and evapotranspiration, wind effect on evapotranspiration, wind damage to plants, transportation of pollen disease and insects by winds, wind profile near ground.
5. Climatic Requirements of Important Crops: Rice, wheat, cotton, soyabean and sugarcane, pearlmilet, groundnut and mustard.
6. Plant and Crop Diseases: The effect of weather on pathogenic agents- Insects, Fungi, Bacteria, Bacilli and Virus, combating plant diseases, natural and artificial methods, the integrated campaign, insect against insects, Bacteria and Bacilli against insect, Virus against Insects, effect of weather on the host.
7. Meteorological Hazards and Agriculture: Frost and frost fighting methods, hail damage and hail modification method, wind damage and wind breakers, Agricultural drought, its severity and management, flood, flood damage and flood fighting.
8. Soils: Composition, structure and physical properties of soils, simple classification of soils, soil air, soil erosion, soil improvement devices and drainage.
9. Agrometeorological forecasts systems, short, medium and long range forecasts, yield forecasts model, system stimulation its concept, application and importance.
10. A brief outline of remote sensing in agriculture.

Suggested Books:

1. Smith: Methods in Agricultural Meteorology
2. Seemann et. al.: Agrometeorology
3. Vitchewich: Agrometeorology
4. WMO Compendium of lecture notes
5. Mavi: Introduction to Agrometeorology

GPM303A: SEISMIC METHODS **Credits: 4**

1. Historical development and background of refraction and reflection methods. Difference between refraction and reflection surveys. System of observations for reflection and refraction surveys. Propagation of seismic waves in homogeneous/ inhomogeneous media, waveforms and their characteristics, N-layered case, continuous increase of velocity. Refraction data interpretation.
2. Seismic data enhancement and test shooting, explosive and non-explosive sources of seismic energy for P-wave, seismic operation on land, common depth point technique, special weathering shots and noise analysis, elevation, weathering and dynamic corrections in refraction and reflection data, random and non random noises, grouping of geophones, diffraction and its analysis, controlled source seismic sounding.
3. Inverse filtering of seismic data, hidden layer problem, sequence of seismic processing, determination of average seismic velocities, principles of tomography, synthetic seismograms.

4. Analysis of multiples and ghost reflections, processing of seismic data, imaging of 2-D, 3-D seismic data, time and depth sections, record surface and reflection surface, vertical and horizontal resolution.
5. Mapping of geological structures (faults, reef, pinchouts, anticlines), migration techniques (classical and modern), wave equation migration, time and depth migration, depositional sequence and pit falls of seismic interpretations.

Suggested Books:

1. Clarbout: Fundamentals of Geophysical Prospecting
2. Telford et. al.: Applied geophysics
3. Sheriff: Seismic Stratigraphy
4. Dobrin & Savit: Introduction to Geophysical Prospecting
5. Waters: Reflection Seismology
6. Sheriff & Geldart: Exploration Seismology

GPM303B: CLIMATOLOGY **Credits: 4**

1. Introduction: Concept of weather and climate, climatic elements, climatic factors, earth-sun relationship, ecliptic and equatorial plane, rotation and revolution of the earth, equinox, solstice, perihelion, cause of seasons, radiation balance.
2. World distribution of isolation, air temperature, mean sea level pressure and wind, effect of land and ocean on circulation, diurnal and annual variations of surface air temperature at different latitudes and over the globe, upper air circulation over the whole world.
3. World distribution of precipitation, effects of continents, oceans and topography on rainfall, diurnal and annual variation of precipitation, world distribution of atmospheric perils.
4. Air masses, their classifications, source regions, modification and associated weather. Extra- tropical cyclones, their origin and associated weather.
5. Climatic Classification: Koppen and Thornthwait schemes applicable to India.
6. Climatic changes and cycles, elements of microclimatology, palaeoclimatology.
7. Indian Climatology: Principal seasons of India, annual and seasonal rainfall and its variability. Definition and concept of drought, aridity, drought indices and drought assessment.
8. Climatic change: climatic system- an overview, observed climate variability and change, physical climate processes and feedback, detection and projection of future climate scenario.

Suggested Books:

1. Sellers: Physical Climatology
2. Trewartha: Introduction to Climates
3. Haurwitz & Austin: Climatology
4. I.M.D. Forecasting Manuals
5. Lockwood: World Climatology

GPM304A: PRACTICAL BASED ON COURSE GPM302A **Credits: 2**

Experiments with resistivity meter.

1. Plotting of equipotential traces and current lines for a point source.
2. Interpretation of S.P. Anomalies.
3. Interpretation of I.P. Data.
4. Interpretation of profiling data.
5. Interpretation of field resistivity sounding curves.
6. Computer-aided interpretation of sounding curve data.

GPM304B: PRACTICAL BASED ON COURSE GPM302B **Credits: 2**

1. To study the Agrometeorological instruments used for observations.
2. Computation of various components of weekly water balance during crop growing period and assessment of agricultural drought.
3. Computation of evaporation, evapotranspiration and potential evapotranspiration using various approaches and methods.
4. Forecasting of crop yield on the basis of weather parameters using crop growth models.
5. Crop phenological changes and heat units requirement of the crops.
6. Prediction of minimum temperature and frost under Eastern UP condition.

7. Medium range weather forecast and preparation of agrometeorological advisory bulletins for farmers.

GPM305A: PRACTICAL BASED ON COURSE GPM303A **Credits: 2**

1. Computation of seismic records and plotting section.
2. Determination of velocity.
3. Interpretation of reflection and refraction data.
4. Plotting of seismic section.
5. Testing and handling of seismic prospecting units.
6. Automatic migration and mapping techniques.
7. Preparation of structural maps.
8. Seismic modelling and working at the seismic signal processing laboratory.

GPM305B: PRACTICAL BASEDON COURSE GPM303B **Credits: 2**

1. Basic analysis of global distribution of mean climatic parameters.
2. Computation of weighted and running means of a time series.
3. Computation of rainfall variabilities and coefficient of variation.
4. Computation of mean wind, resultant wind, prevailing wind and persistence.
5. Computation of climatic types according to Koeppen and Thornthwaite.
6. Exercise in curve fitting, least square, correlation and regression.

GPM306/GPM306B: GEOPHYSICAL FIELD TRAINING **Credits: 2**

Field training of the Second year students (fourth semester) will undergo field training for familiarization at specialized centers/field work for about 2-3 weeks during semester break after third semester and submit the report to the field training Incharge.

GPM307: PRACTICAL BASED ON COURSE GPM301 **Credits: 2**

1. Identification of different phases on a seismogram and to determine the epicentral distance of an earthquake.
2. Determination of group velocity from a record and draw the group velocity dispersion curve.
3. Use of stereographic projection map for locating the epicentre of an earthquake.
4. To prepare the intensity map and find out the epicentre and focal depth for an earthquake.
5. Determination of magnitude from a given seismic records.
6. To draw travel time curve for body waves and find out the velocities of the upper mantle.
7. Demonstration seismological instruments-seismometer.

GPM308M: FUNDAMENTALS OF GEOEXPLORATION **Credits: 3**

1. Basic principles of geophysical exploration.
2. Physical properties of minerals and rocks.
3. Gravity Method: Worden, Lacoste and Romberg, gravimeters, field procedure and reduction of gravity data.
4. Magnetic Method: Flux gate magnetometer, field practices and corrections.
5. Electrical method: elements of SP, IP and resistivity methods, Wenner and Schlumberger configurations, methods of resistivity profiling and sounding, theory of images, Tagg's method of interpretation.
6. Seismic Method: Elementary principle of reflection and refraction methods, two layered reflection and refraction problems, Travel-time curves. Fundamentals of conventional seismic instruments, Fan shooting, Profile shooting.
7. Radiometric Method: Physical and geological principles of radiometric method, GM counter, scintillation counter and gamma ray spectrometer.

Suggested Books:

1. Dobrin & Savit: Introduction to Geophysical Prospecting
2. Parasnis: Principle of Applied Geophysics
3. Telford et al: Applied Geophysics
4. Sharma: Geophysical Prospecting for Geologists and Engineers
5. Israel & Krebs: Nuclear Radiation in Geophysics

SEMESTER-IV

GPM401: MATHEMATICAL METHODS IN GEOPHYSICS Credits: 4

1. Complex variables: Analytic function, Cauchy's theorem, Laurent series, residues of analytic and contour integration, applications in geophysics.
2. Integral transforms: Fourier transform, Laplace transform, Hankel transform, and their applications in geophysics.
3. Numerical solution of partial differential equations: Classification of linear partial differential equations, wave and diffusion equations, Laplace equations, and their applications in geophysics.
4. Orthogonal functions: Bessel's function, Hermite, Laguerre and Legendre polynomials, introduction and applications of orthogonal systems and Green's function, and their applications in solving geophysical problems.
5. Non-linear Systems: Non-linear equations and their application in solving geophysical problems.
6. Analysis of statistical and variance analysis, tests of significance and their applications in geophysics.
7. Finite element methods: Introduction to various element shapes, descritization of structures; applications of finite element and finite difference methods in solving geophysical problems.

Suggested Books:

1. Sastry: Introduction Methods of Numerical analysis
2. Gerald: Applied Numerical Analysis
3. Gerald et. al.: Finite Element Simulation in Surface and Subsurface Hydrology
4. Bath: Mathematical Aspects of Seismology
5. Jain, Iyengar & Jain: Numerical Methods for Scientific and Engineering Computation
6. Jain: Numerical Solution of Differential equations
7. Mitchell: Computational Methods in Partial Differential Equations

GPM402: PETROLEUM GEOPHYSICS AND STRATIGRAPHY Credits: 4

Seismic source energy for S-wave, Shear wave prospecting. Shear wave velocity and shear modulus estimation from P-wave data. Application of shear wave and shear modulus in processing and interpretation of seismic data. Data acquisition for vertical seismic profiling (VSP), 3D-VSP and its applications. Multi-component seismic data acquisition for recording of P and S waves. Relation between rock properties and AVO response, seismic inversion.

4-D and 5-D seismics, passive seismics. AVO/AVA analysis, splitting of P wave energy into P and S seismic reflected and refracted waves, Zoeppritz equations. Offset dependent reflectivity. Seismic stratigraphy and sequence analyses, seismic facies analyses, reflection and amplitude character analyses, bright spot. Seismic lithologic modelling, Vp/Vs and lithology, gas detection using AVO.

Suggested Books:

1. Clarbout: Fundamentals of Geophysical Prospecting
2. Telford et. al. : Applied Geophysics
3. sheriff: Seismic Sratigraphy
4. Dobrin & Savit: Introduction to geophysical Prospecting
5. Waters: Reflection Seismology
6. Sheriff & Geldart: Exploration Seismology
7. Fundamentals of geophysical interpretations by Laurence R. Lines and R.T. Vavrick.

GPM403: INSTRUMENTATION AND SIGNAL PROCESSING Credits: 3

1. Amplitude and frequency response characteristics of geophones, critical and optimum damping, seismic amplifier and its frequency response, principles of magnetic tape recording, digital multiplexed recording and shot moments, principles of binary gain ranging amplifier and floating point, dynamic range, Automatic gain Control (AGC) circuit, Programmable Gain Control (PGC), timing system and recording formats (SEG A,SEG B and SEG C).
2. Pilot balloon, theodolite, radiosonde, rawin and radar, radiation instruments. Automatic weather station, VHRR, VTPR, APT, VHPR.

3. Analogue filters: Low and high pass filters and their alpha/beta diagrams, Characteristic impedance of symmetrical T and pie networks; band pass, comb, and active filters.
4. Analogue and digital signal recording and processing: mechanisms of signal recordings. Transmission and receiving of meteorological data through satellite. Wireless seismic recording. Seismic signal recording and enhancement of S/N ratio, Satellite digital data process: retrieval technique, cloud top temperature, S.S.T. Retrieval algorithms, very high resolution radiometer, vertical temperature profile radiometer, automatic picture transmission, vertical humidity profile radiometer.
5. Different types of display of digital and magnetic recording wiggle trace, variable area and variable density records.

Suggested Books:

1. Kennedy & Davis: Electronic Communication Systems
2. Anstey: Seismic Prospecting Instruments Vol. 2
3. Ryder: Network, Lines and Fields
4. Rabinet & Gold: Theory and application of Digital Signal Processing
5. Remote sensing of the atmosphere: J.T. Houghton, F.W. Taylor and C.D. Rodgess.
6. Satellite meteorology: An introduction- S.Q. Kidder and T.H. Vanderhaor
7. Introduction to environmental remote sensing: E.C. Barette and L.F. Curtis.

GPM404A: GRAVITY AND MAGNETIC METHODS **Credits: 4**

1. Basic Theory: Magnetic elements I.G.R.F., inverse square law, concept of potential, Poisson's and Laplace's equations, magnetism on atomic scale, Dia- para- ferro magnetic materials, susceptibilities and densities of various rocks and minerals, factors affecting density and susceptibilities, and susceptibility determination.
2. Instrumentation: gravity prospecting instruments: borehole and airborne gravimeters, magnetic prospecting instruments, Rubidium vapour magnetometer.
3. Data Acquisition and Correction: Aeromagnetic surveys, plan of the field surveys, station spacing, corrections for gravity and magnetic data, calculation of derivatives, continuation methods, polynomial fitting for regional- residual separation of gravity and magnetic anomalies, filter theory and filtering of potential field data, Gravity anomalies over spheres, cylinders, dykes, faults and sheets, Magnetic anomalies over single pole, dipole, line pole, spheres, cylinders, faults and dykes, graticules and anomalies of irregular bodies, relation between gravity and magnetic potentials, depth estimation, curve matching techniques, transformation of gravity and magnetic anomalies in frequency domain, spectral representation of field data and interpretation of gravity and magnetic profiles.
4. Processing and interpretation.
5. Gravity and magnetics for the exploration of the minerals, oil/gas and groundwater.

Suggested Books:

1. Grant & West: Interpretation Theory in Applied Geophysics
2. Nettleton: Gravity and Magnetics in Oil Prospecting
3. Rao & Murthy: Gravity and Magnetics
4. Dobrin & Savit: Introduction to Geophysical Prospecting
5. Telford et. Al: Applied Geophysics
6. Murthy & Mishra: Interpretation of Gravity and Magnetic Anomalies in Space and Frequenies Domain

GPM404B: DYNAMIC METEOROLOGY **Credits: 4**

1. Principles of thermodynamics: First law of thermodynamics, internal energy, specific heat capacity and enthalpy, adiabatic process, entropy and the second law of thermodynamics.
2. Thermodynamics of water Vapour and Moist Air. Isotherms on an □, e diagram, equation of state of moist air, Clausius Clapeyron equation, adiabatic processes of saturated air and moisture variables.
3. Thermodynamics Diagrams: General considerations, emagram, tephigram, skew T/ log P diagram, stuve diagram, choice of a diagram.
4. Hydrostatic Equilibrium: Hydrostatic equation, geo-potential height computations for upper-air sounding, hydrostatic of homogeneous, isothermal, constant lapse rate and dry adiabatic atmosphere, standard atmosphere.
5. Hydrostatic Stability and Instability: General consideration, slice method, entrainment.
6. Fundamental forces, gravitation and gravity, geo-potential.

7. Equation of motion in different coordinate systems, tangential, local, rectangular coordinates, spherical polar coordinates, natural coordinates, scale analysis of the equations of motion, approximate equations, Rossby number.
8. Continuity equation in cartesian, isobaric and spherical coordinate.
9. Balanced Motion: Inertial wind, geostrophic wind, gradient wind, cyclostrophic wind and thermal wind.
10. Viscosity and Turbulence: Fundamental laws of viscosity, equations of mean motion in turbulent flow, mixing length theory, planetary boundary layer, power law, Ekman layer, Richardson number, Rrynold's number, Froud number.
11. Circulation and Vorticity: Kelvin's circulation theorem, Bjerknes theorem, potential vorticity, vorticity equation, divergence equation, Helmholtz theorem.
12. Tendency equation, Bjenknes Holmboe theory, isallobaric wind.
13. Vertical Motion: Kinematic, adiabatic and omega equation.

Suggested Books:

1. Hess: Introduction to Theoretical Meteorology
2. Pisharoty: Thermodynamic Diagram and some of Their Uses (IMD Tech. Note)
3. Gordon: Introduction to Dynamic Meteorology
4. Holton: An Introduction to Dynamic Meteorology
5. Haltiner: Numerical Weather Prediction
6. Haltiner & Martin : Physical and Dynamic Meteorology
7. Haltiner & William: Numerical Weather Prediction and Dynamic Meteorology
8. Astel & Wiin-Nielsen: Compendium of Meteorology, Vol. I. Dynamic Meteorology, W.M.O. No. 364

GPM405A: WELL LOGGING AND RESERVOIR GEOPHYSICS Credits: 4

1. Reservoirs characteristics and objectives of well logging. Reservoir Rocks: Clastic and carbonate rocks. Reservoir Properties: Porosity, permeability, fluid saturation, need of drilling fluids and its properties, invasion process and various profiles, classification of formation evaluation methods, objective of well logging methods, logging operational field system and its procedure.
2. Electric-Logging: Spontaneous Potential (SP) logging: Spontaneous potentials in boreholes and its sources, SSP and its measurements, SP curves and its interpretation factors affecting the shape and amplitude of SP curve, Non-focussed, focused and induction logging, principles and sondes, Interpretation of electric Log Data: Determination of resistivity of interstitial water Rw, porosity and water saturation Sw of clean and shaly sandstones, determination of Rw of clean sandstone from SP curve, estimation of permeability.
3. Radiation Well Logging: Gamma ray logging, details of the radiation logging, density or gamma-gamma logging, principle of the neutron-gamma logging, neutron-epithermal-neutron logging, neutron-thermal-neutron logging, interpretation and applications of radiation logging for evaluation of reservoir characteristics.
4. Other Miscellaneous Logging Techniques: Acoustic velocity (Sonic) logging, Cement Bond Log (CBL), Litho-density Tool (LDT), Thermal log, caliper or section gauge log, Casing Collar Locator's (CCL), dip and direction logging, gravity logging, nuclear magnetic resonance logging.
5. Advanced Logging Tools: Introduction of induced gamma-ray spectrometry, chlorine logging, introduction to natural Gamma-ray Spectrometry (NGS), Cased Hole Neutron Tool (Thermal Decay Time or TDT) measurements.
6. Cross Plots: Resistivity-porosity cross plots, Porosity Cross plots: neutron-density, sonic density and sonic neutron density cross plots. Application of well logging to ground water mineral and petroleum resources.

Suggested Books:

1. Lynch: Formation Evaluation
2. Wyllie: Fundamentals of Well Log Interpretation
3. Vaish : Geophysical Well Logging : Principles and Practices
4. Schlumberger: Schlumberger Log Interpretation Principles/ Applications
5. Schlumberger: Schlumberger Log Interpretation Charts
6. Serra: Fundamentals of Well - Log Interpretation
7. Pirson: Hand book of Well log Analysis for Oil and Gas Formation Evaluation
8. Deveton: Log analysis of subsurface Geology: Concepts and Computer Methods.

GPM405B: PHYSICAL METEOROLOGY **Credits: 4**

1. Radiation: Laws of radiation, nature of solar radiation, solar constant, geographical and seasonal distribution of solar radiation, direct beam normal flux at the earth's surface, direct beam insolation at the earth's surface, Basis of Elsasser treatment, Elsasser chart; radiative heating and cooling, radiative equilibrium and the stratosphere, mean heat balance of the earth atmospheric system, poleward transport of energy, fundamental link with general circulation, radiation parameterization.
2. Cloud Physics: Atmospheric aerosols and condensation nuclei, nucleation, physics of initial stages of condensation, curvature and solution effect, growth and evaporation of cloud droplets by diffusion, the physics of precipitation in warm clouds, collision-coalescence theory, collection efficiency, terminal velocity, precipitation from mixed clouds, Bergeron and Findeisen's theory, artificial cloud seeding of warm and cold clouds, rain making experiments and weather modification, cumulus parameterization, horizontal and vertical diffusion.
3. Atmospheric Optics: Attenuation of light, refraction, scattering, turbidity, optical phenomena, rainbow, halo, corona, glory, mirage etc., atmospheric and terrestrial refraction, looming, towering, stooping, sinking.
4. Radar Meteorology: Basic radar equation, wavelengths used for detection of cloud, thunderstorm and cyclone, PPI and RHI scopes, meteorological applications of radar, radar echoes, estimation of precipitation, rain water content and upper winds using radar.
5. Atmospheric Ozone: Mechanism of formation and destruction, measurement of ozone, Dobson's ozone spectrometer, seasonal and latitudinal variation, Umkehr effect, vertical distribution of ozone, ozone-weather relationships, ozone hole.
6. Atmospheric Electricity: Electrical field of the earth in fair and disturbed weather, atmospheric ionization, air-earth electric current and its maintenance, supply current, theories of charge generation and separation in thunderstorm, lightning discharges.
7. Satellite Meteorology: Equation of orbital motion, types of meteorological satellites, description of important sensors on board, visible and infra red data and their interpretation, identification of typical weather systems from cloud picture, estimation of winds, vertical temperature and humidity profile and rainfall from satellite observations, tropical cyclone grading using Dvorak's technique.

Suggested Books:

1. Johnson: Physical Meteorology
2. Mason: Physics of Cloud
3. Dobson: Exploring the Atmosphere
4. Retallack: Compendium of Meteorology Vol. I, Part-III, Physical Meteorology. W.M.O. 364
5. Baton: Radar Observes the Weather
6. Kidder & Vonder Harr: Satellite Meteorology
7. Taba: Ozone Observations an Introduction and their Meteorological Applications, W.M.O. Technical Note No. 36, W.M.O. No. 108
8. Haltiner & Williams: Numerical Prediction and Dynamic Meteorology

GPM406A: PRACTICAL BASED ON COURSE GPM404A **Credits: 2**

1. Determination of density by Nettleton method.
2. Handling of gravimeter and its calibration.
3. Structure contouring from subsurface informations
4. Preparation of a residual map by (a) Graphical method and (b) Grid method.
5. Upward and downward continuation of gravity and magnetic fields.
6. Computation of gravity effect of a sphere, horizontal cylinder and fault.
7. Computation of effect of a magnetic dipole of finite length, sphere and horizontal cylinder.

GPM406B: PRACTICAL BASED ON COURSE GPM404B **Credits: 2**

1. Analysis of tephigram: (a) Computation of derived parameters, LCL,CCL and LFC, (b) Computation of precipitable water content, (c) Computation of heights of pressure surfaces by adiabatic and isothermal methods, (d) Study of stability and instability of various layers and forecasting of fog, thunderstorm, etc., (e) Determination of height of tropopause, thickness of isothermal and inversion layers etc.

2. Preparation of geostrophic wind scale and computation of geostrophic wind from constant pressure charts with the help of above scale.
3. Computation of geostrophic vorticity, geostrophic wind.
4. Exercise in graphical addition and subtraction.

GPM407A: PRACTICAL BASED ON COURSE GPM405A Credits: 2

1. Qualitative interpretation of well logs and their correlation
2. Computation of porosity.
3. Computation of formation factor.
4. Computation of water saturation.
5. Computation of oil saturation.
6. Computation and estimation of producible oil per acre.
7. Applications of cross plots for estimation of various parameters.

GPM407B: PRACTICAL BASED ON COURSE GPM405B Credits: 2

1. Measurement of total amount of atmospheric ozone by Dobson's ozone spectrophotometer.
2. Numerical computation in radiation, atmospheric optics, cloud physics, satellite meteorology and radar meteorology.

SEMESTER-V

GPM501: ADVANCED COMPUTER PROGRAMMING Credits: 3

1. Programming Language C: Constants, variables, data types, expressions operators, conditional statements, iterative statements, array, function, storage, class, pointers, structure, union and file handling.
2. Object Oriented Programming: Procedural approach VI, object approach, object oriented methodology, concept of object and class, reusability, encapsulation and polymorphism.
3. C++ An Object Oriented Language: Class, object, constructor, destructor, operator, overloading, function overloading, inheritance, virtual function, multiple inheritage, generic classes.
4. Software: application software, system software, support software and firmware.
5. Introduction to UNIX operating system.
6. Introduction to JAVA, Visual BASIC and data base management system.
7. Internet, intranet, multimedia and LAN.

Suggested Books:

1. Balagoswami: Programming in C
2. Gotfried: Programming in C
3. Yashwant Kanetkar: C Programming
4. Yashwant Kanetkar: C++ Programming
5. Robert Lafore: Object Oriented Programming C++
6. Hasbest Scheilds: Object Oriented Programming
7. Stephen Prata: Advanced Unix-A Programmers Guide

GPM502: COMMUNICATION THEORY Credits: 4

1. Introduction: Historical development of time series, classification of data, analogue and discrete signals, digitization, sampling interval and aliasing, wavelets, Z transform, linear system, Dirac delta function and impulse response of a linear system, impulse response function, minimum delay, maximum delay and mixed delay wavelets.
2. Convolution and Correlation Techniques: Convolution, method for Convolution, properties of Convolution, autocorrelation, cross-correlation, and their applications, time domain and frequency domain concepts.
3. Fourier series and Fourier transform, Hilbert transform, Walsh transform, orthogonal function and Dirichlet conditions, complex form of Fourier Series and Fourier transform, physical significance and interpretation of Fourier transform, properties of Fourier transform, Fourier transform of a symmetrical rectangular pulse, reciprocity Fourier transform (FFT), two dimensional Fourier transform and its applications.

4. Digital Filtering: Low, high and band pass filters, truncation of unit impulse response function, illustration of Gibb's phenomenon. Butterworth filters, Chebysev filter, recursive filters.
5. Weighting Functions (Windows): Hamming window, Hamming window and their comparison, triangular window, Bortlett window, practical applications of windows.
6. Techniques for Spectral Estimation: Power spectrum, method for calculation of power spectrum, three basic data models, Moving Average (MA) method, Maximum Entropy Method (MEM), Maximum Likelihood Method (MLM), Autoregressive process (AR), comparison of MA, MEM, MLM and AR techniques.
7. Deconvolution: Introduction, white spectrum, Wiener inverse and its mathematical details, homomorphic applications of deconvolution filtering.
8. Applications of Time Series in various branches of Geophysics: Seismic method, gravity and magnetic methods, resistivity and well-logging methods, use of spectral techniques in meteorology, oceanography and groundwater hydrology.

Suggested Books:

1. Silvia & Robinson: Deconvolution of Geophysics Time Series in the Exploration for Oil and Natural Gas
2. Robinson & Trietel: Geophysical Signal Analysis
3. Kanasevich: Time Sequence Analysis in Geophysics
4. Bath: Spectral Analysis in Geophysics
5. Oppenheim & Schafer: Digital Signal Processing
6. Papoulis: The Fourier Integral and its Applications

GPM503A: GEOELECTROMAGNETIC METHODS Credits: 4

1. Basic Principles and Theory: Maxwell's equations, electromagnetic potential and wave equations, boundary conditions, long wavelength approximation, depth of penetration, electromagnetic field due to straight wire, rectangular and circular loops, elliptical polarizations, amplitude and phase relations, real (in phase) and imaginary (quadrature) components.
2. Methods of Prospecting: Bieler Watson method, Dip angle methods-fixed vertical loop transmitter, broadside and shoot back methods, two frame method, compensator method, Turam method, Moving source-receiver methods- horizontal loop (Slingram) method, AFMAG and VLF methods, Airborne EM systems- rotary field method, INPUT method, EM profiling and sounding.
3. Interpretation: Principles of EM similitude and modelling, response of conducting sphere to uniform alternating magnetic field and infinitely long horizontal cylinder to line source, response of sheet conductors to dip angle, Turam and horizontal loop EM systems, dip angle characteristic curves and phasor diagrams for horizontal loop EM system for sheets, effect of overburden on EM anomalies, Principles and practices of Ground Penetrating Radar.
4. Magnetotelluric (MT) method: Origin and characteristic of MT fields, MT instrumentation, field practices, MT effect over a conducting half space and two layer model.

Suggested Books:

1. Parasnis: Mining Geophysics
2. Grant & West: Interpretation Theory in Applied Geophysics
3. Telford et. al: Applied Geophysics
4. Patra & Mallick: Geosounding Principles Vol.II
5. SEG Publication: Mining Geophysics Vol. II

GPM503B: SYNOPTIC AND TROPICAL METEOROLOGY Credits: 4

1. Meaning and scope of synoptic meteorology, Plotting of synoptic observations on different maps, analysis of surface and upper air charts, vertical time section and cross section analysis.
2. Scales of Atmospheric Weather Systems: Primary, secondary and tertiary circulations.
3. Kinematics of horizontal motion, characteristics of wind fields, construction of streamlines, isotach, trajectories, relation between stream line and trajectories, Blatons equation.
4. Kinematics of pressure fields, mechanism and influence of pressure changes.
5. Frontogenetical Functions: Frontogenesis in horizontal velocity field, frontogenetical and frontolytical sectors, kinematic and dynamic boundary conditions, pressure distribution over front, Morgules formula.
6. Jet streams, their classification and characteristics, PFJ, STJ, TEJ, low level jet stream of Asian monsoon, structure, formation, maintenance and associated weather, zonal index, index cycle, cutoff lows, highs, blocking.

7. Principle of Weather Prediction: Short range, medium range and long range weather prediction, limits of predictability, forecast evaluation.
8. Tropical Meteorology: Mean tropical atmosphere, equatorial trough (ITCZ), basic currents, trade wind inversion, easterly waves and their dynamical aspects, formation and forecasting of easterly waves, QBO.
9. Tropical cyclones, classification of tropical disturbances, global climatology, life cycle, surface and upper air structure, thermal structure, the eye and wall cloud, rainfall, energy aspects, theories of formation, CISK, detection, movement tracks, recurvature, Fujiwara effect, forecasting, storm surges, cyclone warning.
10. Monsoons: Monsoon regions in the tropics, causes of monsoon, the Indian summer monsoons, rainfall distribution, elements of the monsoon system, monsoon disturbances, MTC, monsoon variability, onset and advancement of monsoon, withdrawal, fluctuations in monsoon activity, active, weak and break monsoon conditions, intra seasonal and inter-annual variability of summer monsoon, biweekly and 30-50 day oscillation, southern oscillation and El Nino, monsoon rainfall and teleconnections, long range prediction of monsoon, monsoon over China, S.E. Asia, N. Australia, east and west Africa.
11. General Circulation Features over India during other seasons: Winter seasons, western disturbances, cold waves, fog, Pre Monsoon Seasons: different convective phenomenon, Norwesters and tropical storms, Post monsoon Season: N.E. Monsoon, tropical storms and their differences with tropical storms of pre monsoon season.

Suggested Books:

1. Riehl: Tropical Meteorology
2. Palmen & Newton: Atmospheric Circulation System
3. Reiter: Jet Stream Meteorology
4. Ramage: Monsoon Meteorology
5. Saucier: Principles of Meteorological Analysis
6. Wiin-Nielson: Compendium of Meteorology, Vol. I, Part 3, Synoptic Meteorology, Geneva, W.M.O. No. 364.
7. Asnani: Tropical Meteorology,Vol. I and II
8. Das: Monsoons, Geneva, WMO No. 613
9. Keshavamurty & Sankar Rao: The Physics of Monsoons
10. Tarakanov: Tropical Meteorology
11. Krishnamurthi: Compendium of Meteorology, Vol. II, Tropical Meteorology, Geneva, W.M.O. No,364

GPM504A: DIGITAL ELECTRONICS AND MICROPROCESSOR Credits: 4

1. Number Systems: Decimal, binary, octal and hexadecimal number systems, Interconversion of decimal, binary and hexadecimal numbers, BCD numbers, BCD addition and subtraction.
2. Logic gates: AND, OR, NOT, NAND, NOR, and exclusive OR gates, NAND and NOR gates as universal gates.
3. Logic Families: TTL logic circuits (NAND and NOR gates), comparison of TTL, ECL and CMOS.
4. Boolean Algebra: De Moegan's theorems, standard POS and SOP forms, min-term and max-term representation of Boolean functions, simplification of Boolean functions using K-maps (up to 4 variables).
5. Combinational Circuits: Half and full adders, half and full subtractors, multiplexer, demultiplexer, encoder, decoder, BCD to seven segment decoder.
6. Flip-flops: R-S, J-K, master-slave and edge triggered J-K, T and D Flip-flops.
7. Sequential Circuits: Shift registers, ring counters, ripple and synchronous counter, modulo-N counter, decade counter, digital-to analog converter (binary weighted register and ladder types), and analog -to-digital converter (using D/A converter and comparator).
8. Digital Wave form Generator: Concept of timer IC 555 and its use for waveform generation (astable and monostable).
9. OP-AMP: Concept and characteristics of OP-AMP and its use as: Adder, subtractor, differentiator, integrator, logarithmic and exponential operator, inverting and non-inverting amplifier, differential amplifier, CMRR, analog computer (for 2^{nd} order differential equations).
10. Memories: Concept of Random Access Memory (RAM) , static and dynamic RAM, Read Only Memory (ROM), PROM and EPROM.
11. Introduction to Microprocessors: Evolution of microprocessors, organization, architecture and pin description of 8085 microprocessor, addressing modes and instruction set, input/ output interfacing

devices (8255, 8251), simple programs for addition/ subtraction, developmental trends in microprocessors technology (8086, 80186, 80286, 80386, 80486 and Pentium).

12. Application of Microprocessors: Application of Microprocessors in Geophysical Instrumentation: Microprocessors based data acquisition, frequency, temperature and voltage measurements using microprocessors.

Suggested Books:

1. Jain: Modern Digital Electronics
2. Malvino: Digital Computer Electronics
3. Puri: Digital Electronics
4. Mathur: Introduction to Microprocessors
5. Sheth & Hebber: Microprocessors
6. Gaonkar: Microprocessors Architecture, Programming and Applications
7. Ram: Microprocessors and Microcomputers
8. Gaikwad: Operational Amplifier.

GPM504B: ADVANCED DYNAMIC METEOROLOGY Credits: 4

1. Numerical Weather Prediction: Historical review, filtering of sound and gravity waves, filtered forecast equation, forecasting of stream function. Barotropic model, equivalent barotropic model, baroclinic model-two level, multilevel quasigeostrophic model, primitive equation models, spectral and finite element model, Sigma coordinate, hydrodynamic equations in Sigma coordinate Eta coordinate, Eta model, precipitation forecasting, range of predictability.
2. Objective analysis: Cressman method, method of optimum interpolation, initialization: static initialization, dynamic initialization, normal mode initialization, Newtonian relaxation or Nudging, nonlinear stability, Aliasing, Arakawa Jacobian, Staggered grid systems.
3. Hydrodynamic Instability: Barotropic, inertial and baroclinic instability.
4. Numerical Methods: Finite difference, truncation error, linear computational instability, Neuman condition, implicit and semi-implicit method, relaxation method, simultaneous and sequential.
5. Atmospheric Waves: Perturbation theory, properties of waves, sound waves, gravity waves, vertical stability, internal gravity waves, Rossby waves, mountain waves.
6. Scale analysis of momentum, continuity, vorticity, divergence, thermodynamic and omega equation, diagnostic analysis of synoptic scale motion in middle latitude.
7. Sutcliffe's Development Theory: Thickness and vorticity advection.
8. General Circulation: Longitudinally averaged and varying flow, constraints on the theories of the general circulation, maintenance of mean zonal circulation (angular momentum consideration), experimental approach.
9. Energetics: Energy equation, internal and available potential energies, generation, conversion and dissipation of energies.

Suggested Books:

1. Hess: Introduction to Theoretical Meteorology
2. Holton: An Introduction to Dynamic Meteorology
3. Haltiner: Numerical Weather Prediction
4. Haltiner & Martin: Dynamic and Physical Meteorology
5. Atkinson: Dynamic Meteorology: An Introductory Selection
6. Thompson: Numerical Weather Analysis and Weather Prediction
7. Wiin-Nielsen: Compendium of Meteorology, Vol. I Geneva, W.M.O.

GPM505A: PRACTICAL BASED ON COURSE GPM503A Credits: 2

1. Computational of dip angle response over sheet type bodies.
2. Analysis of dip angle data and its interpretation.
3. Computation of Turam profiles over sheet type bodies.
4. Reduction of Turam data and its interpretation.
5. Interpretation of Slingram profiles over sheet conductors using phasor diagrams.

GPM505B: PRACTICAL BASED ON COURSE GPM503B Credits: 2

1. Plotting and analysis of surface weather charts for different seasons and issue of inferences.

2. Plotting and analysis of constant pressure charts.
3. Plotting and analysis of vertical time section and cross section chart.
4. Streamline and isotach analysis.
5. Prognostication of synoptic systems like lows, trough etc. by kinematic methods.
6. Computation of zonal index.

GPM506A: PRACTICAL BASED ON COURSE GPM504A Credits: 2

1. Experiment with logic gates.
2. Experiment with Flip-flops.
3. Experiment with digital ICs.
4. Experiment with 555 timer.
5. Experiment with microprocessors.

GPM506B: PRACTICAL BASED ON COURSE GPM504B Credits: 2

1. Preparation of Bellamy grid and computation of divergence, vorticity and deformation field by Bellamy grid.
2. Preparation of curvature circle nomogram and computation of divergence and vorticity by curvature circle.
3. Computation of divergence and vorticity by finite difference method.
4. Problems in dynamic Meteorology.
5. Simple exercises in numerical model.

GPM507: PRACTICAL BASED ON COURSE GPM501 Credits: 2

1. Numerical solution of non-linear equations using available software.
2. Solution of differential equations using available software.
3. Interpretation of data by finite difference method.
4. Development of programme and solution of some problems by finite element method.

GPM508: PRACTICAL ON GEOPHYSICAL DATA PROCESSING Credits: 2

1. To digitize analogue signal by graphical method choosing different sampling intervals, plotting the digitized record and examining the aliasing phenomenon.
2. To convolve the two signals (wavelets), plot and examine the results.
3. To compute the autocorrelation and cross-correlation functions for a given data set, plot and examine the results.
4. To perform digital filtering after designing a low, high and band pass filters and to examine the effects of truncation.
5. To apply Hanning and Hamming windows on a given set of data points.
6. To compute the amplitude, phase and power spectra of a given time series.
7. To apply Wiener inverse filtering to seismic data, comment on wavelet extraction problems.
8. To perform the spectral analysis of gravity, magnetic and meteorological data.
9. Computer modelling of some geophysical problems.

SEMESTER-VI

GPM601: PHYSICAL OCEANOGRAPHY AND MARINE GEOPHYSICS Credits: 4

Section I: PHYSICAL OCEANOGRAPHY Credits: 2

1. Physical properties of Sea Water: Chlorinity, salinity, thermal properties, density, pressure, optical properties, transmission of sound, water masses, T-S diagram, variation of salinity, heat budget of the ocean, Bowen ratio.
2. Acquisition of Ocean Data: Salinity measurements, Nansen bottle, light in sea, measurement of SST, reversing thermometers, Bathy thermograph, current meters.
3. Ocean Currents: Hydrodynamic equations of motion, inertia currents, geostrophic currents in homogeneous and stratified ocean; relative and slope currents, thermohaline currents, drift current in

homogeneous water, Ekman theory, the major surface current systems of the ocean, upwelling and sinking with special reference to Indian ocean and their effects.

4. Waves: Wave velocity, group velocity, theory of surface gravity waves, short and long waves, generation and growth of wind waves, long waves in canals, standing waves in closed basins, seiches, swell, breakers and surf, internal waves, storm surges, tsunami.
5. Tides: Tide generating forces, principal harmonic components, theories of tides, description and types of tides, prediction of tides, tidal gauges.
6. Air Sea Interaction: Structure of the boundary layer, exchange coefficients and profiles, transfer of heat and water vapour.

Section II: MARINE GEOPHYSICS **Credits: 2**

1. Ocean and Seas: classification, growth and decline of ocean basins, turbidity currents, submarine sedimentation and stratigraphy, physiography and divisions of the sea floor, continental shelves, slopes, aprons and abyssal planes, occurrence of mineral deposits and hydrocarbon in offshore.
2. Gravity and magnetic Surveys: Types of magnetometer used in a survey ship, towing cable and fish, data collection their reduction and interpretation, underwater gravity measurements, ship borne gravimeters, Graf sea gravimeter, vibrating string accelerometer, Lacoste Romberg gravimeter, problems with shipborne gravity measurements, survey procedure, data reduction and interpretation.
3. Seismic Surveys: Marine energy sources, Finger, Boomer, Sparker, explodor, airgun, vapour cook etc. hydrophones active section and streamer towing gear, shooting methods near offshore and offshore exploration techniques, analysis of seismic data their processing and interpretation, refraction survey with Sonobuoy's and interpretation.
4. Radio Positioning System: Short range and long range Doppler Sonar, satellite navigation, GPS & GIS.

Suggested Books:

1. Duxbury: The Earth and its Oceans
2. WMO No.364: Marine Meteorology
3. Sverdrup, Johnson & Fleming: The Oceans
4. Defant: Physical Oceanography, Vols. I and II
5. McLellen: Elements of Physical Oceanography
6. Jacob, Russel & Willson: Physics and Geology
7. Dobrin & Savit: Introduction to Geophysical prospecting
8. Telford et.al.: Applied Geophysics

GPM602(P-Z): ELECTIVE PAPER **Credits: 4**

GPM602 (P-Z): [ELECTIVE PAPER]

GPM602P: ADVANCED HYDROLOGY

1. Surface water, evaporation formulae and theories of surface flows, safe yield, floods, estimation of flood flow, method of unit hydrograph, synthetic hydrographs, their application, flood routing through rivers and reservoirs, statistical methods in hydrology.
2. Water resources: Partially saturated soils, Darcy's law in unsaturated medium, derivation of Darcy's law from Navier stokes theorem, different forms of unsaturated flow equation, nature of the physical parameters in unsaturated flow, infiltration theories, concepts of diffusion, dispersion and redistribution in groundwater, groundwater hydrographs, application of finite difference and finite element techniques, simulation method, analog and digital modelling of aquifers, tracer techniques.
3. Water Management: urban hydrology, practical aspects of flow of groundwaters to wells, analysis of pumping test, conservation and utilization of water and its management.

Suggested Books:

1. Ward: Principles of Hydrology
2. Todd: Groundwater Hydrology
3. Heath & Trainer: Introduction to Groundwater Hydrology
4. Guide Book on Nuclear Techniques in Hydrology
5. Dury: Face of the Earth
6. Chow: Handbook of Applied Hydrology
7. Childs: Introduction to Soil Water Physics

8. Walton: groundwater Evaluation
9. Tolman: Groundwater.

GPM 602Q: ADVANCED SEISMOLOGY

1. Measurement and characteristics of strong ground motion, dispersion of surface waves, ray theory, travel-time curves for body waves and inversion techniques, tomography, 3-D earth structure, attenuation, diffraction and scattering of seismic waves, fault asperities inferred from seismic waves, crust and mantle structures inferred from surface waves, broad band seismometry, and recent Indian earthquakes.
2. Seismic arrays, tectonic and volcanic earthquakes and their characteristics, seismic hazard, risk analysis, seismic gaps and regions of high seismic potential, earthquake source studies, earthquake processes and source modeling, earthquake prediction problem, application of fractals and chaotic dynamics in seismology, non-linear propagation and geodynamics.

Suggested Books:

1. Kanamori & Baschi: Earthquakes: Observation, theory and Interpretations
2. Ewing: Elastic Waves in Layered Media
3. Bath: Mathematical Aspects of Seismology
4. Bullen: Introduction to Seismology
5. Aki & Richard: Quantitative Seismology, Vol. I and II
6. Slawomir & Andrezej: An Introduction to Mining Seismology.

GPM 602R: REMOTE SENSING AND GIS

1. Fundamentals of Remote Sensing: Energy sources, principles of solar and terrestrial radiation, laws of radiation, energy interactions, spectral patterns and signatures.
2. Characteristics of aerial photographic imagery, photogrammetry, airphoto interpretation for terrain evaluation.
3. Application in geological mapping and mineral resource evaluation, concepts of GIS and applications, theory and principles, structural concepts, geological interpretation and its ambiguity, geological guides, characteristics for mineral resource.
4. Application to water resources evaluation and soil moisture determination; watershed parameters, physiographic measurements, surface water, flood plain delineation, precipitation, ice and snow monitoring, evaporation and evapotranspiration, subsurface water information system and analysis.
5. Developments of satellites and remote sensing developments in India.
6. Development in remote sensing platforms, constant level and tethered balloons, aircrafts, rockets and satellites.
7. Kepler's laws of planetary motion, circular and elliptical orbits of satellites, polar, geosynchronous and geostationary satellites.
8. Types of sensors, photographic and TV cameras, visible and infrared sensing, radiometer, side looking radar.
9. Historical development, various meteorological satellite system, INSAT system, data acquisition system, Automatic Picture Transmission (APT).
10. Remote sensing application in meteorology , visible and infrared pictures of clods, recognition of various clouds and weather systems, estimation of surface temperature and cloud tops, vertical profiles of temperature and water vapour, wind estimation, role of weather satellites in global coverage of observation in synoptic and climatological studies.

Suggested Books:

1. Barret & Curtis: Introduction to Environmental Remote Sensing.
2. Lillesand & Kiefer: Remote Sensing and Image Interpretation.
3. Reeves (Ed.): Manual of Remote Sensing, Vols. I and II, American Soc. Photogrammetry.
4. Siegal & Gellospie: Remote Sensing in Geology.
5. Teekshadulu & Rajan: Remote Sensing , Indian Academy of Sciences.
6. Kidder & Vonder Haar: Satellite Meteorology an Introduction.

GPM602S: ENVIRONMENTAL GEOPHYSICS

1. Earth and environment, elements of environment, man and environment.

2. Atmosphere : Origin, composition and structure, the troposphere as an Environmental layer, air pollution, pollutants and its impact on weather, the ozone shield, green house effects and role of trace gases, global warming, acid rains.
3. Hydrosphere: Ocean and environment, the hydrologic cycle and global water balance, surface water hydrology, water pollutants and their effects on surface and ground water, heavy mentals (Hg, Cd and As) in ground water, their detection and abatements.
4. Mineral resources and environment, impact of mining and mineral resources.
5. Energy and Environment: Coal, oil and gas, geothermal energy, nuclear energy, solar energy.
6. Role of geophysics in Environmental protection.

Suggested Books:

1. Jorgensen: Principles of Environmental Sciences and Technology
2. Keller: environmental geology
3. Ramade & Strahler: Environmental Geoscience-Interaction Between Natural System and Man
4. Tyler & Mitter: Jr. Environmental Science
5. Sharma: Environmental Geophysics

GPM602T: GEOMAGNETISM

1. Earth's Magnetic Field: Internal and external fields, main field and variational field, components of the main field, magnetic and geomagnetic coordinates, measurement and recording of the main field: measurements of horizontal, vertical, declination, inclination and total field, magnetometers and variographs, Theories of the earth's main magnetic field: A brief introduction of the various of the main field and its secular variation, dynamo theory of the main field, Geomagnetic indices: Ci, CR, Ks, Kp indices, concepts of quiet and disturbed days.
2. Transient Variations: Definition, computation, morphological features, current systems and causes of solar quiet day variation (Sq), disturbance daily variation SD, storm time variation Dst and lunar variation L, Morphology of the equatorial electrojet, geomagnetic storms: morphological features of geomagnetic storms, gradual and sudden commencement storms, DS and Dst fields, ring current, Van allen belts theories of the geomagnetic storms.
3. The Sun, Sunspots and Solar Flares: A brief introduction of the structure of the sun, morphological features and classification of sun sport indices, morphological features of solar flares, classification of solar flares, Morphological feature, classification and causes of auroras, Morphological features, classification, observation and causes of geomagnetic micropulsation, morphological features, composition, structure and production of various layers of the ionosphere, sudden ionospheric disturbances, Earth currents, its measurements, morphological features and interrelation with geomagnetism.

Suggested Books:

1. Chapman & Bartels: Geomagnetism
2. Matsushita & Campbel: Physics of the Geomagnetic Phenomena
3. Jacob: Earth's Core and Geomagnetism
4. Mitra: Upper Atmosphere

GPM602U: NON-LINER SYSTEMS IN GEOPHYSICS

1. Kinematics of deformation - the deformation gradient tensor, the strain tensor, homogeneous deformations, deformation of surface and volume elements, material and spatial coordinates, analysis of stress, Cauchy's equation of motion, balance laws, constitutive equations for elastic and thermoelasticity.
2. Introduction to constructive aspects of bifurcation and implicit function theorem, imperfect bifurcation, bifurcation and non-linear eigen value problems.
3. Non-Linear stability and folding of rock strata, convection in magma chambers and mantle, core convection and dynamo theory, earthquakes and chaos.
4. Non-linear elastic waves and solutions, group velocity, dynamical treatment, fractals and multifractals measures in geophysics.

Suggested Books:

1. Alkin & Fex: An Introduction to the theory of Elasticity
2. Fang: Foundation of Solid Mechanics
3. Mal & Singh: Deformation of Elastic soils

4. Spencer: Continuum Mechanics
5. Robinowitz: Application of Bifurcation Theory
6. Atherton: Stability of Non-Linear System
7. Bhatnagar: Non-Linear Waves in One-Dimensional Dispersive Systems

GPM603V: GEOTOMOGRAPHY AND COMPUTER MODELLING

1. Concept of Tomography: Inversion, linear and non-linear inversion, inversion technique-traditional, Monte-Carlo, Backus-Gilbert, Tau method, non-linear least square, ray tomography, diffraction tomography, borehole tomography, 2D and 3D imaging, applications in various branches of geophysics.
2. Finite element and finite difference methods and their formulations, numerical modelling, super computers, Lax- Wondroff second order scheme, MacDormack fourth order scheme, stability conditions, computer simulation of P-SV, SH and acoustic cases and other geophysical problems.

Suggested Books:

1. Mitchell: Computational Methods in Partial Differential Equations
2. Noye: Numerical Simulation fluid Motion
3. Krishnamurthy & Sen: Computer Based Numerical Algorithms
4. Gold & Rader: Digital Processing of Signals
5. Boarding er. al.: Application of Seismic Travel Time tomogrphy
6. Dines& Lytle: Computerized Geophysical Tomography
7. Wu et. al.: Diffraction Tomography and Multisource Holography Applied to Seismic Imaging.
8. Aiyer et. al.: Geotomography.

GPM602W: MODERN TECHIQUES IN SEISMIC INTERPRETATION AND MIGRATION

1. Seismic Sources: Explosive and non-explosive sources.
2. Seismic Refraction Method: Travel time equations for simple one layer case and for variable velocity case, expressions for dipping layer and faulted bed cases, Gardener delay time method, hidden layer problems, field techniques for refraction survey, fan shooting.
3. Seismic Reflection Method: The travel time equations for horizontally layered medium, expressions for dipping interfaces, field techniques for reflection survey, split spread, end on spread, broad side configurations, 2D, 3D and 4D configurations, common depth point technique, presentation formats of seismograms, selection of field survey parameters.
4. Data processing sequence, static and dynamic correction, weathering and datum corrections, CDP stacking, migration and depth section preparation.
5. Velocity Depth Determination: Velocity-depth relation from measurements in boreholes, velocity depth relation from surface observations, T^2-X^2, T-ΔT and hyperbola method.
6. Noise Elimination Method: The structure of noise and its classification using frequency and spatial filters (arrays), multiples identification, suppression of multiples VSP.
7. Mapping of hydrocarbon bearing and water bearing structures, gas hydrates, pattern recognition, thin bed modelling, seismic lithologic modelling, geological interpretation, location of stratigraphic traps, direct detection of hydrocarbons, wave equation migration and its various forms, artificial intelligence, artificial neural network (ANN) and gas detection using AVO analysis.

Suggested Books:

1. Dobrin & Savit: Introduction to geophysical Prospecting
2. Telford et.al.: Applied Geophysical
3. Keary & Brooks: Introduction to Geophysical Exploration
4. Waters: Reflection Seismology
5. Robinson: Basic Exploration Geophysics
6. Scheriff: Seismic Stratigraphy
7. Lavergne: Seismic Methods.

GPM602X: ADVANCED PHYSICAL METEORLOGY

1. Physics of tropical monsoon clouds, precipitation mechanism from convective, stratiform and orographic clouds, artificial modification of the precipitation, artificial dissipation of fog and low cloud, atmospheric electoral and boundary layer processes.
2. Precipitation chemistry, aid rain, atmospheric aerosols and trace gases, tropospheric chemistry.

3. Atmospheric chemistry, dynamics of the middle atmosphere and troposphere-stratosphere coupling, monsoon activity, climatic change, measurement of atmospheric minor constituents and climatic effects.
4. Physics of the Upper Atmosphere: Composition and structure, energy exchanges by collisions, transport processes, mean circulation and eddy transport, the ionosphere, composition and general properties, observational methods, aurora and air glow, noctilucent clouds, nacreous clouds.
5. Atmospheric Visibility: Attenuation of light by the atmosphere, the air-light and visual range in daytime, visibility of point light sources at night, objective measurement of visual range, oblique visual range.
6. Meteorological Acoustics: Doppler effect, effect of temperature and humidity on sound velocity, sound path in a calm atmosphere, effect of wind on sound propagation, attenuation of sound, propagation of sound through stratosphere, sound origination from meteorological elements.
7. Meteorological Physics: Coronas and related phenomenon, twilight phenomenon, colour and polarisation of sky light.

Suggested Books:

1. Johnson: Physical Meteorology
2. Mason: Physics of Cloud
3. Dobson: Exploring the Atmosphere
4. Retallack: Compendium of Meteorology Vol. I, Part-III, Meteorology. W.M.O. 364
5. Baton: Radar Observes the Weather
6. Kidder & Vonder Harr: Satellite Meteorology
7. Mitra: The Upper Atmosphere.

GPM602Y: APPLIED METEOROLOGY

1. Aviation meteorology: Requirements of climatological data for sitting of runways, meteorological observations and forecasts required for aircraft operations, organization of KAO, DGCA and air traffic control, coordination between MFT and ATC, special observations for aviation, METAR, SPECT, TREND, SIGMENT, aviation forecasts and warnings, documentation and briefing for national and international flights, aviation climatology.
2. Maritime Meteorology: Voluntary observing flight routine and special observations from ship at sea weather bulletins for shipping, storm warning bulletins, storm signals at ports, weather routing of ships, climatological atlas for oceanic regions, atlas of storm tracks.
3. Biometeorology: Thermal balance between heat production and heat loss effect of climatic factors, influence of weather and diseases caused by viruses, bacteria and metabolic disorders, acclimatization, climate and insect pests, thermal comfort and comfort indices, urban and building climatology.
4. Environmental Pollution: Extent of pollution, atmospheric ventilation, meteorological factors affecting the concentration of pollutants, monitoring for prevention control of pollution UNEP.
5. Atmospheric Transport and Diffusion: Classical diffusing theory (K-theory), similarity theory, theory of turbulence, Plum rise, short term modelling and prediction technique for pollutants.
6. Effects of air pollution on climate, human health.

Suggested Books:

1. Stern: Air pollution
2. HMSO, London: Handbook of Aviation Meteorology
3. Munn: Biometeorology
4. WMO Note: Urban Climatology
5. WMO Technical Note: Air Pollutants, Meteorology and Plant Injury.

GPM602Z: ADVANCED CLIMATOLOGY

1. Climatic classification based on atmospheric circulation and geographical conditions. Genetic classification, classification based on the effect originated at the surface. Types of climate, Various classifications of climate, Koepen, thornthwaite, Handdel etc.
2. Function and physical description of the climates of the different continents and ocean.
3. Radiation properties of natural surfaces, radiation in crops forest canopies, cities, vertical variation and distribution of various climatic elements, heat exchange and conduction near soil surface, atmospheric pollution.

4. Elements of bioclimatology, urban building climatology, climatic change, fundamental meteorological factors affecting the climate, past climate revealed by meteorological observation, methods of palaeoclimatology, possible causes of climatic change, influence of man on climatic changes, climatological statistics.
5. Introduction to climate system, role of green house gases, global warming, climatic change and its impacts on agriculture.
6. Asian Summer Monsoon: Global teleconnections, basic concepts of climatic modelling, energy cycle, Tropical Ocean and their role in climate control.
7. Physical processes in general circulation.

Suggested Books:

1. Miller: Climatology
2. Lamb: Climate Present, Past and Future
3. Barry & Parry: Synoptic Climatology
4. Stringer: Fundamentals of Climatology
5. Winter School on Climate Change and its Impacts, IIT, Delhi.

GPM603: SEMINAR **Credits: 2**

Each student is required to prepare a seminar note (about 1500 words) in the form of a report and give oral lecture (40 minutes) on the topic assigned by the Head of the Department in consultation with respective supervisor.

GPM604A/GPM604B: COMPEHENSIVE VIVA- VOCE **Credits: 3**

At the end of sixth Semester, each student will be examined in this paper on the entire M.Sc. (Tech.) Geophysics courses by a Board consisting of three internal and one external examiner in each specialization.

GPM605A/GPM605B: PROJECT WORK/DISSERTATION **Credits: 8**

During sixth semester, students may go for 2-4 weeks for their Project work/dissertation at the laboratories of their field of specialization or with field parties depending upon the facilities in the summer vacation. For dissertation work, the co-supervisor is also allowed. The topic of their project work/dissertation will be decided towards the end of the fourth Semester by the Head of the Department in consultation with the supervisors.

NOTE

1. *Students of Semester-IV will initiate dissertation/ project work during summer vacation at laboratories outside Varanasi, if required.*
2. *Students of Semester-II will carry out Summer Training at different laboratories outside Varanasi, if desired by the students.*
3. *Students of Semester-III will carry out their Field Training during the Semester Break.*
4. *For dissertation work, the co-supervisor(s) be allowed for the outside organization.*

M.A./ M.Sc. HOME SCIECE (FOODS & NUTRITION)
Department of Home Science
Banaras Hindu University

Semesterwise distribution of Courses and Credits

Semester-I		
Course Code	**Titles**	**Credits**
HFM101	Research Methods and Scientific writing	3
HFM102	Applied Physiology	3
HFM103	Nutritional Biochemistry and Methods of Investigation	3
HFM104	Institutional food Administration	3
HFM105	Women's Health and Nutrition	3
HFM106M	**Minor Elective:* Indian Socio-economic environment and perspectives	3
HFM107	*Practicals based on course* HFM101	2
HFM108	*Practicals based on course* HFM102	2
HFM109	*Practicals based on course* HFM103	2
	Total	**24**
Semester-II		
HFM201	Statistics	3
HFM202	Advanced Nutrition -I	4
HFM203	Food Safety, quality control and sensory evaluation of foods	3
HFM204	Food Science and Microbiology	3
HFM205	Science and Technology for Rural Development	3
HFM206M	**Minor Elective:* Computer application	3
HFM207	*Practicals based on course* HFM203	2
HFM208	*Practicals based on course* HFM204	2
	Total	**23**
Semester - III		
HFM301	Pilot Survey for Dissertation and Synopsis Formulation and Seminar	4
HFM302	Experimental Foods	3
HFM303	Advanced Nutrition - II	3
HFM304	Nutritional Epidemiology	3
HFM305	Community Nutrition	3
HFM306M	**Minor Elective:* Development Project Management	3
HFM307	*Practicals based on course* HFM302	2
HFM308	*Practicals based on course* HFM303	2
	Total	**23**
Semester -IV		
HFM401	Dissertation	6
HFM402	Therapeutic Nutrition and Biochemical correlates	3
HFM403	Internship (6-8 weeks spread over two years)	9
HFM404	*Practicals based on course* HFM402	2
	Total	**20**
	Grand Total	**90**

* To be opted by all students specializing in Extension and Communication

Ist Semester

Major Elective

HFM101: RESEARCH METHODS AND SCIENTIFIC WRITING Credits 3

PART – A – RESEARCH METHODS

Science, scientific methods, scientific approach

Role of statistics and research in Home Science discipline: Objectives of research: Explanation, control and prediction.

Types of Research: Historical, survey, experimental, case study, social research, participative research. Definition and Identification of a Research Problem**,** Selection of research problem**,** Justification**,** Theory, hypothesis, basic assumptions, limitations and delimitations of the problem.

Types of variables

Theory of probability: Population and sample**,** Probability sampling: systematic random sampling, two stages and multi stage sampling, cluster sampling, Non-Probability sampling: purposive, quota and volunteer sampling/snowball sampling.

Basic Principles of Research Design and hypothesises: Purposes of research design; Fundamental, applied and action exploratory and descriptive experimental, survey and case study, ex-post facto, Longitudinal and cross sectional

Qualitative Research Methods: Theory and design in qualitative research, Definition and types of qualitative research, Methods and techniques of data collection, Informal group discussions**,** Interviews; Key informants, in-depth interviews**,** Observations

Data Gathering Instruments: Observation, questionnaire, interview, scaling methods, case study, home visits, reliability and validity of measuring instruments.

Scales of measurement and the appropriate statistical techniques.

Critical analysis of research.

References

1. Bandarkar, P.L. and Wilkinson, T.S. (200): Methodology and Techniques of Social Research, Himalaya Publishing House, Mimbai.
2. Bhatnagar, G.L. (1990): Research Methods and Measurements in Behavioural and Soxial Sciences, Agri. Cole Publishing Academy, New Delhi.
3. Dooley, D. (1995): Strategies for interpreting Qualitative Data; Saga Publications, Claifornia.
4. Gay, L.R. (1981, 2nd Ed.): Educational Research, Charles, E. Merill, Columbus, Ohio.
5. Long, J.S. (Ed.) (1988): Common Problems Proper Solutions: Avoiding Errors in Quantitative Research Beverly Hills, Sage Publications, California.
6. Mukherjee, R. (1989): The Quality of lIfe: Valuation in Social Research, Saga Publications, New Delhi.
7. Stranss, A. and Corbin, J. (1990): Basis of Qualitative Research: Grounded Theory Procedures and Techniques, Saga Publications, California.

PART – B – SCIENTIFIC WRITING

Scientific writing as a means of communication: Different forms of scientific writing Articles in journals. Research notes and reports. Review articles, Monographs, Dissertations, Bibliographies.

How to formulate outlines: The reasons for preparing outlines**,** guide for plan of writing**,** skeleton for the manuscript**,** Kinds of outline**,** topic outlines**,** conceptual outline**,** sentence outlines**,** combination of topic and sentence outlines

Drafting Titles, Sub Titles, Tables, Illustrations: Tables as systematic means of presenting data in rows and columns and lucid way of indicating relationships and results, formatting Tables: Title, Body stab, Stab Column, Column Head, Spanner Head, Box Head, appendices; Use and guidelines

The writing process: Getting started**,** Use outline as a starting device**,** Drafting**,** Reflecting, Re-reading**,** Checking organization**,** Checking headings**,** Checking content**,** Checking clarity**,** Checking grammar**,** Brevity and precision in writing**,** Drafting and Re-drafting based on critical evaluation

Parts of Dissertation/Research report/Article: Introduction**,** Review of Literature**,** Method**,** Results and Discussion**,** Ask questions related to content, continuity, clarity, validity internal consistency and objectivity during writing each of the above parts.

Writing for Grants: Clearly state the question to be addressed**,** Rationale and importance of the question being address**,** Emperial and theoretical conceptualization**,** Presenting pilot study/data**,** Research proposal and time frame**,** Clarity, specificity of method**,** Clear organization**,** Outcome of study and its implications**,** Budgeting**,** Available infra-structure and resources**,** Executive summary

PRACTICAL

HFM107: RESEARCH METHODS AND SCIENTIFIC WRITING (Credits 2)

1. Abstract of different types of research should be given and discussed in the practical classes.
2. Students should be asked to collect data from the household of B.H.U. Campus by using different sampling techniques in a group.
3. The Student should be given exercises on different kinds of Scientific Report writings.
4. Presentation should be made by the students on their field work reports.

References

1. APA (1984): Publication Manual of American Psychological Association (3rd Edition), Washington, APA
2. Copper, H.M. (1990): Integrating Research: A Guide for Literature Reviews (2nd Edition), California, Sage.
3. Dunn, F.V. & Others (ed.) (1994): Disseminating Research Changing Practice, NY: Sage.
4. Haman, E. & Montagnes, I. (Eds.) (1997): The Thesis and the Book, New Delhi: Vistaar.
5. Locke, L.F. and Others (1987): Proposals that work: A Guide for Planning Dissertations & Grant proposals (2nd Ed.), Beverly Hills: Sage.
6. Mullins, C.J. (1977): A Guide to Writing and Publishing in Social and Behavioral Sciences, New York: John Wiley & Sons.
7. Richardson, L. (1990): Writing Strategies, Reaching Diverse Audience, California: Sage.
8. Stemberg, R.J. (1991): The Psychologist's Companion: A Guide to Scientific Writing for Students and Researchers, Cambridge, OUP.
9. Thyer, B.A. (1994): Successful Publishing in Scholarly Journals, California: Sage.
10. Wolcott, H.F. (1990): Writing up Qualitative Research Newbury Park: Sage.

Core Course

HFM102: APPLIED PHYSIOLOGY Credits 3

General Physiology: Revision of structure of cells tissues, muscles, organs, system phenomena of life, constancy of internal environment.

Body Fluids: Blood; Blood composition, volume, plasma proteins; origin, composition and function, blood groups. Red blood cells; structure and functions, origin and life history; number of blood cells in the blood, Haemoglobin, its composition and functions Regulation of red blood cell formation.

Circulatory System: Working of the heart, anatomy, properties of heart muscle: Origin of the heart beat, heart; sounds, control of heart rate, reflexes involving the heart, velocity of blood flow, resistance to blood flow and blood pressure. Blood vessels, arteries, capillaries, veins, control of blood vessels, pulse physiological constancy of blood pressure. Origin and propagation of cardiac cycle.

Digestive System: Review of structure and function, Secretary, digestive and absorptive functions, Role of liver, pancreas and gall bladder and their dysfunction Motility and hormones of GIT.

Respiratory System: Organs, structure, function, composition of inspired and expired and alveolar air respiration internal and external, its rate, factors affecting it, artificial respiration anoxia.

Excretory System: Urinary system, organs, structure, function, mode of formation of urine, process of maturation, Skin-its structure and function, Temperature of the body and its regulation, maintenance of acid-base balance, electrolytes.

Reproduction: Reproductive organs-the ovary, development of graffian follicle, the testis, maturation of the sperm, fertilization development of the ovum, implantation, pregnancy, fetal membrane, parturition, lactation and its regulation, ovarian and uterine cycle and their regulations, Effect of hormones on menstruation, ovulation.

Musculoskeletal System and sensory organs:

The spinal cord and brain, the neurons synapses, chemical, theory of conduction across nerve, pathways of the spinal cord, Reflux action, kinds of reflexes, functions of the different part of the brain, Sensory mechanisms, Different kinds of receptors with reference to the sense organs, Automatic nervous system sensory organs; Eyes, Ear, Nose, Tongue and Skin.

Endocrine System: Endocrine glands and their hormones, hormonal regulation of function.

Immune System: Cell mediated and humoral immunity Activation of WBC and production of antibodies, role in inflammation and defence

HFM108: APPLIED PHYSIOLOGY PRACTICALS **Credits 2**

1. Examination of slides of connective tissues, nerve tissues, muscular tissues, epithelial tissues. Section of kidney, skin, respiratory tract, lung, blood vessels, ovary tests, uterus, endocrine glands, different regions of the alimentary canal, digestive glands.
2. Recording of number and type of respiration, vital capacity, artificial respiration.
3. Estimation of haemoglobin; blood film preparation, staining, blood grouping and matching study of cells in normal coagulation of blood, Clotting and bleeding time, colour index, Heart sound, blood pressure, pulse, clinical examination and recording.
4. Urine examination – normal abnormal physical examination and chemical examination, estimation of sugar and albumin.

References:

1. Ganong, W.F. (1985): Review of Medical Physiology, 12th Edition, Lange Medical Publication.
2. Moran Campell E.J., Dickinson, C.J. Slater, J.D. Edwards, C.R.W, and Sikora K (1984): Clinical Physiology, 5th Edition, ELBS, Blackwell Scientific Publications.
3. Guyton, A.C. (1985): Function of the Human Body, 4th Edition, W.B. Sanders Company, Philadelphia.
4. Guyton, A.C. and Hall, J.B. (1996): Text Book of Medical Physiology, 9th Edition, W.B. Sanders Company, Prism Books (Pvt.) Ltd., Bangalore.
5. Wilson, K.J.W. and Waugh, A. (1996): Ross and Wilson Anatomy and Physiology in Health and Illness, 8th Edition, Churchil Livingstone.
6. McArdle, W.D., Katch, F. I. and Katch, V.L. (1996): Exercise Physiology, Energy, Nutrition and Human Performance, 4th Edition, Williams and Wilkins, Baltimore.
7. Jain, A.K.: Textbook of Physiology. Vol. I and II. Avichal Publishing Co., New Delhi.

HFM103: NUTRITIONAL BIOCHEMISTRY AND METHODS OF INVESTIGATION **Credits 3**

PART – A - NUTRITIONAL BIOCHEMISTRY

Scope and importance of Biochemistry, Important physical phenomenon influencing the reactions of living matter; Surface tension, Colloidal state, Permeability, Osmotic pressure Hydrogen ion concentration, Chemistry of carbohydrates; glycolysis, gluconeogenesis, citric acid cycle, hexose monophosphate way path, Chemistry of lipids; beta oxidation, synthesis and break down of unsaturated fatty acids, cholesterol, phospholipids, triglycerides,

Chemistry of proteins, Amino Acids, peptide linkage, Nucleic aids, DNA replication and transcription, regulation of gene expression protein synthesis, RNA, Electrolytes, pH buffers, Chemistry of vitamins sources requirements, functions, deficiency, Chemistry of minerals and trace elements, water balance, Acid base balance, Detoxification in the body; metabolism of foreign compounds.

PART – B - METHODS OF INVESTIGATION

Electrolytic dissociation: Acids, bases, salts, buffers, Hendersen; Hasselbach equation.
Theory of indicators and principles of measurement of pH.

Basics of Instrumentation: Physico; chemical principles and methodology; Colorimetry, photometry, fluorimetry, flame photometry and atomic absorptiometry.

Chromatography: Principles and application in paper (circular, ascending and descending), ion-exchange, column, thin layer, gas liquid and high performance liquid chromatographic techniques.

Electrophoresis: Principle and applications in paper and gel electrophoresis.

Bioassays: Animal studies, Human studies, Microbiological assays.

Use of Isotopes: Radioactive and stable isotopes.

NMR and its applications.

Immunological Methods: RIA, ELISA.

PRACTICALS

HFM109: NUTRITIONAL BIOCHEMISTRY AND METHODS OF INVESTIGATION (Credits 2)

PART – A- NUTRITIONAL BIOCHEMISTRY

This course will enable the students to:
Perform biochemical analysis with accuracy and reproducibility.

1. **Proteins:** Estimation of protein in food stuffs, Estimation of albumin, globulin and albumin/globulin ratio in serum and urine, Estimation of hemoglobin.
2. **Glucose:** Estimation of glucose in blood and urine.
3. **Cholesterol**: Estimation of cholesterol in blood.
4. **Urea and Creatinine**: Estimation of urea and creatinine in serum and urine.
5. **Survey of pathological laboratories:** To obtain information about the methods used for blood/serum analysis.

PART – B – METHODS OF INVESTIGATION

Objectives

This practicals will enable the students to :

1. Orient them selves regarding the use of various analytical techniques for specific estimations.
2. Comprehend better the principles involved in different methods of investigation.
3. Become efficient in the use of some of the most commonly used techniques and instruments in High quality research.
4. **Acid and Alkalis:** Preparation of dilute solutions of common acids and alkalis and determining their exact normalities.
5. **Buffers:** Preparation of phosphate, carbonate-bicarbonate, boric acid, acetate, chloride and pthalate buffers and determination of their pH by the use of indicators and pH meters.
6. **Spectrometry:** Beer Lambert Law, absorption maximum, preparation of standard curve and nutrient estimations in UV and visible range, AAS, AES, Flamephotometry.
7. **Fluorimetry:** Estimation of thiamin and riboflavin.
8. **Chromatography:** Paper; Identification of amino acids by circular, ascending and descending methods. Ion-exchange; separation of amino acids. Column - Separation of proteins. Thin layer; Identification of amino acids. Gas-liquid; Estimation of fatty acids. HPLC – Estimation of β-carotene and α-tocopherol.

9. **Electrophoresis**: Fractionation of plasma proteins.

References:

1. Boyer, R. (2000). 3rd Ed. Modern Experimental Biochemistry. Person Education, Asia.
2. Dawes, E.A. (1980) 6th Ed. Quantitative Problems in Biochemistry. Longman Group Ltd.
3. Khosla, B.D., Garg, V.C. and Khosla, A. (1987). 5th Ed. Senior Practical Physical Chemistry. R. Chand and Co., New Delhi.
4. Oser, B.L. (1965). 14th ed. Hawk's Physiological Chemistry. Tata McGraw-Hill Publishing Co. Ltd.
5. Raghuramulu N.; Madhavan Nair and K. Kalyanasundaram, S. (1983). A Manual of Laboratory Technique. NIN, ICMR.
6. Sharma, B.K. (1999). 8th Ed. Instrumental Methods of Chemical Analysis. Gel Publishing House.
7. Srivastava, A.K. and Jain, P.C. (1986). 2nd Ed. Chemical Analysis: An Instrumental Approach. S. Chand and Company. Ltd.
8. Varley, H.; Gowenlock, A.H. and Bell. M. (1980). 5th ed. Practical Clinical Biochemistry. Heinemann Medical Books Ltd.
9. Vogel, A.I. (1962). 3rd Ed. A Textbook of Quantitative Inorganic Analysis by the English Language Book Society and Longman.
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11. Nelson, D.L. and Cox, M.M. (2000): 3rd Ed. Lehninger's Principles of Biochemistry, Macmillan Worth Publishers.
12. Devlin, T.M. (1997): 4th Ed. Textbook of Biochemistry with Clinical Correlation; Wiley Inc.
13. Stryer, L. (1998): 4th Ed. Biochemistry, WH Freeman and Co.
14. Conn, E.E., Stumpf, P. K. Bruening, G. and Doi, R.H. (2001): 5th ed. Outlines of Biochemistry, John Wiley and Sons.
15. Voet, D. Voet, J.G. and Pratt, C.W. (1999): Fundamentals of Biochemistry.
16. Oser, B.L. (1965): 14th ed. Hawk's Physiological Chemistry. Tata McGraw-Hill Publishing Co. Ltd.
17. Varley, H. Gowenlock, A.H. and Bell, M. (1980). 5th ed. Practical Clinical Biochemistry, Heinemann Medical Books Ltd.
18. Tietz, N.W. (1976) Fundamentals of Clinical Chemistry, WB Saunders Co.
19. Vogel, A.I. (1962). 3rd ed. A Textbook of Quantitative Inorganic Analysis. The English Language Book Society and Longman.
20. Raghuramulu, N.; Madhavan Nair and K. Kalyanasundaram, S. (1983). A Manual of Laboratory Techniques. NIN. ICMR.
21. King, E.J. and Wootton, IDP (1956). 3rd ed. Micro-Anlysis in Medical Biochemistry. J and A Churchill Ltd.
22. Plummer, D.T. (1987). 3rd ed. An introduction of Practical Biochemistry. McGraw Hill Book Co.
23. Winton, A.L. and Winton, K.B. (1999). Techniques of Food Analysis. Allied Scientific Publishers.

Code: HFM104: INSTITUTIONAL FOOD ADMINISTRATION **Credits 3**

Introduction to Food Service Systems, Evolution of the food service industry, Characteristics of the various types of food service units, Approaches to Management, Theories of management, Aspects of management, Styles of management, Management tools, Strategies in Planning, Conceptual strategy, Marketing strategy, Financial strategy, Types of plans, Management of Resources, Finance, Determining the finance needed to establish or run an

unit, Budgets, Sources of finance, Planning adequate cash flow, Space & Equipment, Steps in planning layouts, Determining equipment, Selection and placement, Layout analysis, Material, Menu planning, Planning the material needed, Methods of selection, Storage, Quantity food production, Service and modes of delivery, Planning Menus, banquet, outdoor, catering, packed meals, Restaurant, Staff, Manpower planning, Manpower placement, Recruitment, induction, training, motivation and performance appraisal, Time and Energy, Measures for utilisation and conservation, Techno-economic feasibility of food production/service enterprise, Cost Accounting / analysis, Food cost analysis, Records to be maintained, Reports and trend analysis, Marketing and sales management, Marketing strategies, Sales analysis, Market promotion, Quality assurance, Food quality, Total quality management, Market Survey and analysis of processed and finished products, Visit to any food service unit

References:

Management

1. West, B Bessie & Wood, Levelle (1988) Food Service in Institutions 6th Edition. Revised by Harger FV, Shuggart SG & Palgne-Palacio June Macmillian Publication Company New York.
2. Sethi Mohini (1993) Catering Management An Integrated Approach 2nd Edition Wiley Publication.
3. Kotas Richard & Jayawardardene, C (1994): Profitable Food and Beverage Management, Hodder & Stoughton Publication.
4. Brodner, J., Maschal, H.T., Carlon, H.M. (1982): Profitable Food and Beverage Operation 4th Edition, Hayden Book Company, New Jersey.
5. Green, E.F., Drake, G.G. Sweeny, J.F. (1978) Profitable Food and Beverage Management; Planning, Operations, Hayden Book Company, New Jersey.
6. Knootz, H, O Donnel C (1968): Principles of Management McGraw Hill Book Company.

Personnel Management

7. Desseler, Garry (1987) Personnel Management Modern Concepts and Techniques, Prentice Hall, New Jersey.
8. Kumar, H.L. (1986) Personnel Management in Hotel and Catering Industries, Metropolitan Book Company N. Delhi.
9. Hitchcock, M.J. (1980): Food Service System Administration, Macmillan Publishing Company.

Cost Control

10. Keiser, J & Kaillo, E. (1974): Controlling and Analysis of Cost in Food Service Operations, Wiley and Sons N. York.
11. Khari, W.L. (I) (1977): Introduciton to Modern Food and Beverage Service. (1979) Advanced Modern Food and Beverage service. Printice Hall Series.
12. Coltman, M.M. (1977): Food and Beverage Cost Control. Printice Hall Series.
13. Levson (1976): Food and Beverage Operation Cost Control & System Management. Printice Hall Series.

Layout and Design

14. Kazarian, E.A. (1989) Food service Facilities Planning. 3rd Editon, Von Nostrand Reinhold.
15. Kotschwar, L.H. & Terrell, M.E. (1977): Food Service Planning and Layout and Equipment 3rd Edition John Wiley and Sons, N York.
16. Avery, A.C. (1980): Modern Guide to Food Service Equipment. Boston CBI Publishing Company.
17. Brichfield, J. (1988): Design and Layout of Food Service Facilities, New York. Van Nortrand Reinhold.

18. Tovel, A.P. (1984): Standardising Food Service for Quality and Efficiency. AVI Publishing Company INC.

Code: HFM105: WOMEN'S HEALTH AND NUTRITION **Credits 3**

Role of Women in National Development: Women in Family and Community**;** Demographic changes, menarche, marriage, fertility, morbidity, mortality, life; expectancy, sex ratio, aging and widowhood, female-headed families.

Women and Work: Environmental stress, nutrition, health and gender, living conditions, occupational health, health facilities.

Women's nutritional requirements and food needs.

Women and Society: Women's role, their resources and contribution to family and community and effect on nutritional status, Effect of urbanisation on women, Impact of economic policies, industrialization and globalization on women.

Women and Health: Health facilities**,** Disease patterns and Reproductive health**,** Gender and health**,** Health seeking behaviour**,** Women; pregnancy and lactation**,** Safe motherhood**,** Care of at-risk mothers**,** Family planning**,** Women and aging; Special concerns in developed and developing societies: menopause, osteoporosis, chronic degenerative diseases, neurological problems, Women and AIDS

Women and nutrition: Situation of women in global, national and local context, Improving the nutritional and health status, Interventions throughout the life cycle.

Policies and legislations: CEDAW (Convention on Elimination of all forms of Discrimination Against Women), Women's Right to Life and Health (WRLH), Legal status of women.

Empowerment of Women: Role of Education and various national schemes and programmes for women development

Problems and issues related to women in India: Child marriage, Female foeticide, infanticide**,** Socialization of girl child**,** Dowry**,** Employment**,** Women in Politics**,** Domestic Violence

Reference

1. ACC/SCN Policy Discussion Papers
2. Wallance, H.M. and Giri, K. (1990): Health Care of Women and Children in Developing Countries, Third Party Publishing Co., Oakland, California.
3. UNICEF (1994): The Urban Poor and Household Food Security, UNICEF.
4. IDRC (1993): Gender, Health and Sustainable Development.
5. NGO Committee on UNICEF (1997): Women and Children in Urban Poverty – What Way Out?
6. Census Reports, Government of India.
7. NFHS Reports
8. UNICEF – State of the World's Children.
9. Weil, D.E.C.; Alicbusan, A.P.; Wilson, J.F.; Reich, M.R. and Brdley, D.J. (1990). The impact of Development Policies on Health. A Review of the Literature, World Health Organization. Geneva.
10. International Nutrition Foundation – Micronutrient Initiative (1999): Preventing Iron Deficiency in Women and Children; Technical Consensus on Key issues.
11. Gopalan, C. and Kaur, S (Eds) (1989): Women and Nutrition in India, Nutrition Foundation of India.

Minor Elective

Code: HFM106M : INDIAN SOCIO-ECONOMIC ENVIRONMENT PERSPECTIVES **Credits 3**

Indian economy—structure and organisation of rural, urban and tribal areas: Land ownership, occupational hierarchy, dependence on agriculture**,** Caste, class and institutions**,** Roles and status of women**,** Poverty, inequality, unemployment, stagnation**,** Impact of industrialisation of urban life; socio-economic aspects of metropolitan life, Historical overview of tribal welfare.

Socio economic changes since independence: Economic planning and achievements**,** Growth vs Development, Development index, PWLI, HDI, CPI, etc.**,** Rural development; concepts, objectives, importance and historical overview**,** Employment policy; cottage and small industries**,** Land reforms; future programmes**,** Tribal development strategies and policies**,** New economic policy and its impact

Industry and agriculture: Industrial development and diversification**,** Industrial policies since 1981**,** Agriculture price and credit policy**,** New economic policy and agriculture

Co-operatives: Philosophy, objectives, types and progress

References

1. Ahluwalia, M.S. (2000): India's Economic Reforms and Development, Oxford University Press.
2. Bhattacharya, B.: Urban Development in India, Shree Publishing House, Delhi.
3. Bose Ashish: India's Urbanisation, Institute of Economic Growth, Delhi University.
4. Bulsara, J.F.: Patterns of Social Life in Metropolitan Areas.
5. Das Ram: Socio-economic Transformation of Millions through Rural Development, 21st Century Publishers, Meerut.
6. Dreze, J. and Sen, A.K. (1995): India, Economic Development and Social Opportunity, Oxford University Press.
7. Gulati, A: Indian Agriculture and Open Economy.
8. Hussain, N.: Tribal India Today, Hamam Publishing House.
9. Krishan, K.L.: Industrial Growth and Diversification.
10. M.B. Nanavati and Anjana, J.J.: Indian Rural Policies.
11. Sen, A.K.: Growth Economics.
12. Singh, A.K. : Tribal Development in India, Amar Prakashan, Delhi.

Journals

1. Economics and Political Weekly.
2. Journal of Rural Development
3. Kurukshetra, Publication of Development, Govt. of India, New Delhi.
4. Social Change (Council of Social Development, New Delhi).
5. Vohra, Publication of Development, Govt. of India, New Delhi.

IInd SEMESTER

Major Elective

Code: HFM201: STATISTICS **Credits 3**

Conceptual understanding of statistical measures, Classification and tabulation of data. Measurement of central tendency, measures of variation, Frequency distribution, histogram, frequency, polygons, Oliver, Binomial distribution, Normal distribution; Use of normal probability tables, Parametric and non-parametric tests, Testing of hypothesis; Type I and Type II errors, Levels of significance, Chi-square test, Goodness of fit, Independence of attributes 2×2 and $r \times c$ contingency tables, Application of student 't' test for small samples. Difference in proportion for means and difference in means, Co-relation, coefficient of co-relation, rank co-relation, Regression and prediction, Analysis of variance; one way and two-

way classification, Experimental Designs; Completely randomized design, Randomized block design, Latin square design, Factorial design, Trend analysis.

References

1. Edwards: Experimental Design in Psychological Research
2. Garrett, Heny E. (1971): Statistics in Psychology and Education, David Haley & Co.
3. Kerlinger: Foundation of Educational Research

HFM202: ADVANCED NUTRITION – I **Credits 4**

Energy: Energy content of foods. Physiological fuel value – review. Measurement of Energy Expenditure: BMR, RMR, thermic effect of feeding and physical activity, methods of measurement. Estimating energy requirements of individuals and groups. Regulation of energy metabolism: control of food intake, digestion, absorption and body weight.

Utilization of digestive nutrients and desirability

Carbohydrates: Types, classification, digestion, and transport; review, dietary fibre, fructo-oligosaccharides, resistant starch; chemical composition and physiological effects Glycemic index of foods. Sweeteners nutritive and non-nutritive.

Proteins: Classification, digestion, absorption and transport – review. Metabolism of proteins: Role of muscle, liver and gastro intestinal tract. Protein quality, methods of evaluating protein quality. Protein and amino acid requirements. Therapeutic applications of specific amino acids: Branched chain, glutamine arginine, homocysteine, cysteine, taurine.

Lipids: Classification, digestion, absorption, transport – review. Functions of EFA. Role of n-3, n-6 fatty acids in health and disease. Requirements of total fat and fatty acids. Trans fatty acids. Prostaglandins.

Minerals: (Note: for each nutrient sources, bioavailability, metabolism, function, requirements, RD/ESADDI, deficiency and toxicity, interactions with other nutrients are to be discussed).

Macro minerals: calcium, phosphorous, magnesium, sodium, potassium and chloride.

Micro minerals: Iron, Copper, zinc, manganese, iodine, fluoride.

Trace minerals: Selenium, cobalt, chromium, vanadium, silicon, boron, nickel.

Vitamins: Historical background, structure, food sources, absorption and transport, metabolism, biochemical function, assessment of status. Interactions with other nutrients. Physiological, pharmacological and therapeutic effects, toxicity and deficiency with respect to the following:

Fat soluble: Vitamins A, D, E & K.

Water soluble: Thiamine, riboflavin, niacin, biotin, pyridoxine, folic acid, pantothenic acid, ascorbic acid, cyanocobalamin, choline, inositol.

References:

1. Annual Reviews of Nutrition. Annual Review Inc, California, USA.
2. Shils, M.E.; Olson, J.; Shike, M. and Roos, C. (1998): Modern Nutrition in Health and Disease. 9th edition. Williams and Williams. A Beverly Co. London.
3. Bodwell, C.E. and Erdman, J.W. (1988) Nutrient Interactions. Marcel Dekker Inc. New York.
4. World Reviews of Nutrition and Dietetics.
5. European Journal of Clinical Nutrition.
6. International Journal of Vitamin and Nutrition Research.
7. International Journal of Food Science and Nutrition.
8. Nutrition Research
9. Ann Nutr Metab.

HFM203: FOOD SAFETY, QUALITY CONTROL AND SENSORY EVALUATION OF FOODS

Credits 3

PART – A (FOOD SAFETY AND QUALITY CONTROL)

Introduction to quality assurance and food safety assurance, Current concepts of quality control, Quality assurance programme; Quality plan, documentation of records, products standards, Product and purchase specifications, process control and HACCP, hygiene and housekeeping, corrective action, quality and programme and total quality process.

Product Evaluation: Specifications and food standards. International, National; Mandatory, Voluntary, Tests for specific raw food ingredients and processed, Proximate principles, Nutrient analysis, Quality parameters and tests to adulterants, Consumer Protection.

PART – B (SENSORY EVALUATION OF FOOD)

Introduction to sensory analysis and uses of sensory tests.

General testing conditions.

Selection of test subjects and training of panel.

Types of tests: Discrimination/difference test: Paired test, triangle test and duo-trio test; tests for multiple samples, difference from control/reference, Qualitative Difference Tests; Ranking, Numerical scoring test, magnitude estimation, Descriptive Tests; Rating for sensory profile, Threshold tests**,** Acceptance test; Monadic, paired and sequential monadic.

Descriptive analysis, concept alignment and selection of terms.

Consumer acceptability using sensory evaluation.

PRACTICAL

HFM207: FOOD SAFETY, QUALITY CONTROL AND SENSORY EVALUATION OF FOODS

Credits 2

PART – A –FOOD SAFETY AND QUALITY CONTROL

1. To test different foods for their quality
2. To detect adulteration in different foods.
3. To be familiar with tests used for quality control.
4. Assessment of purity and quality using appropriate standard tests for the following: Milk and milk products, Ice creams and sherbets, Spices and condiments and salt, pickles, sauces and chutneys, Tea and coffee**,** Canned, dehydrated, frozen and bottled fruit/vegetable products, Flesh foods**,** Fruit juices, concentrates and beverages.

PART – B –SENSORY EVALUATION OF FOOD

1. Establishing sensory panels: Selecting and recruiting panelists, screening for trained panels, training panelists, monitoring performance. Recognition tests for 4 basic tastes, odour and aroma. Tests with other senses. Threshold tests.
2. Analytical tests: (i) Difference (ii) Ranking (iii) Descriptive (iv) Scoring and (v) Rating.
3. Planning a Sensory Experiment: (i) Designing the questionnaire and scorecard, (ii) identifying descriptors.
4. Conducting the Test
5. Preparing samples, Presenting samples, Using reference samples, Reducing panel response error, Consumer oriented tests, Product oriented tests, Shell life studios, Product matching, Product mapping, Taint Investigation and Prevention
6. Report Writing

References:
1. Martens, M.; Dalen, G.A.; Russwurm, H. (eds) (1987): Flavour Science and Technology, John Wiley and Sons, Chichester.
2. Jellinek, G. (1985): Sensory Evaluation of Food Theory and Practice. Ellis Horwood, Chichester.
3. Piggott, J.R. (ed.) (1988): Sensory Analysis of Foods. Elsevier Applied Science, London.
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9. Bryan, F.L. (1992): Hazard Analysis Critical Control Point Evaluations. A Guide to Identifying Hazards and Assessing Risks Associated with Food Preparation and Storage. World Health Organisation, Geneva.
10. Food and Agricultural Organisation (1980): Manuals of Food Quality Control. 2. Additives Contaminants Techniques, Rome.
11. Bureau of Indian Standards: Specifications and Standard Methods.
12. Herschderfer (1987): Quality Control in Food Industry, Food Science and technology – A series of Monographs, Academic Press, London.

Code: HFM204: FOOD SCIENCE AND MICROBIOLOGY **Credits 3**

PART – A – FOOD SCIENCE

Introduction to food chemistry

Enzymes: Review of nomenclature, properties and isolation; Factors influencing enzymes, Enzyme inactivation and control, Food modification by enzymes, Immobilized enzymes in food processing, Enzymes in waste management, Enzymes and health/nutrition/food issues

Lipids: Role of food lipids in favour; Effects of processing on chemical structure and physical properties, Precursors of Aroma compounds, Physiological effects of lipids and safety issues, Lipids exposed by frying conditions, hydrogenated fat and irradiated foods, Lipids; protein complexes

Carbohydrates: Use of polysaccharides in food: Individual Polysaccharides; Agar, Aliginates, Carageenans, Gum Arabic, Xanthan, Guar gum, Tamarind flour, Pectins, Polysaccharide hydrolyses**,** Modified Starches; mechanically damaged starches, extruded starches, pregelatinized, tin boiling starch, cross-linked starches, starch ethers and esters, oxidized starches**,** Use of non-starch polysaccharides in food

Flavours: Methods of flavour analysis, Taste and non-specific saporous sensation, Individual aroma compounds: Vegetable, fruit and spice flavour, flavours from lactic acid / ethanol fermentation, flavour volatiles from fats and oils, flavour volatiles in muscles foods and milk, Thermally induced process flavours, Volatiles from oxidative cleavage of carotenoids, Interactions with other food constituents, Natural and synthetic flavours

Food Colorants: Pigments in animal and plant tissues, Food colours; Types and properties, regulatory aspects, safety issues.

Beverages: Harvesting, processing and by-products; Coffee, tea, cocoa, alcoholic beverages.

Problems of chemical residues in food: Recent advances in biotechnology; Recombinant DNA techniques, genetically modified foods.

PART – B – MICROBIOLOGY

Introduction to historical developments in food preservation, spoilage, infections and legislation, Factors affecting the growth of micro-organisms in food, Intrinsic and Extrinsic parameters that affect microbial growth, Methods of Isolation and detection of micro-organisms or their products in food, Conventional methods, Rapid methods (Newer techniques), Immunological methods: Fluorescent, antibody, Radio immunoassay, ELISA etc., Chemical methods: Thermostable nuclear, ATP measurement and PCR (Polymers chain reacitons) – only principles in brief, Spoilage of different groups of foods: Cereal and cereal products, vegetables & fruits, meat & meat products, eggs and poultry, fish and other sea foods, milk and milk products, canned food, Food borne diseases: bacterial, and viral food-borne disorders, Food-borne important animal parasites, Mycotoxins, Role of microbes in fermented foods and genetically modified foods.

PRACTICALS

HFM208: FOOD SCIENCE AND MICROBIOLOGY **Credits 2**

PART – A –FOOD SCIENCE

1. a. Study of structure of starch from different sources. Effect of processing on starch – swelling and retrogradation, starch hydrolysis.
   b. Viscosity measurement – in swelling and gelatinization of starch.
   c. Estimation of starch and non-starch polysaccharides.
2. Thermal stability of protein. Effect of added components; acid, alkali, organic solvents, organic solutes and detergents.
3. a. Effect of Factors affecting fat Lipolysis; Fatty acid composition, temperature, moisture, surface area, presence of pro and anti-oxidants: Measurement of peroxide value, TBA, total and volatile components.
4. Surface tension: Measurement in hydrophilic, hydrophobic fluids and in emulsions.
5. Measurement of browning in a food system.
6. Polyphenol oxidase activity in enzymatic browning

PART – B – MICROBIOLOGY

1. Preparation of common laboratory media and special media for cultivation of bacteria, yeast & molds.
2. Staining of bacteria: Gram's staining, acid-fast, spore, capsule and Flagellar staining, Motility of bacteria, Staining of yeast and molds.
3. Cultivation and identification of important molds and yeast. (Slides and mould culture).
4. Study of environment around us as sources of transmission of micro-organisms in foods. Assessment of surface sanitation of food preparation units' swab and rinse techniques.
5. Demonstration of available rapid methods and diagnostic kits used in identification of micro-organisms or their products.

References:

1. Pelezar, M.I. and Reid, R.D. (1993) Microbiology McGraw Hill Book Company, New York, 5th Edition.
2. Atlas, M. Ronald (1995) Principles of Microbiology, 1st Edition, Mosby-Year Book, Inc, Missouri, U.S.A.
3. Topley and Wislson's (1983) Principles of Bacteriology, Virology and Immunity, Edited by S.G. Wilson, A. Miles and M.T. Parker, Vol. 1: General Microbiology and Immunity, II: Systematic Bacteriology. 7th Edition. Edward Arnold Publisher.

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5. Frazier, W.C. (1988) Food Microbiology, McGraw Hill Inc. 4th Edition.
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8. Garbutt, J. (1997) Essentials of Food Microbiology, 1st Edition, Arnold International Students Edition.
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13. Venderzant, C. and D.F. Splitts Toesser (1992): Compendium of Methods for the Microbiological Examination of Foods 3rd Edition. American Public Health Association, Washington D.C.
14. Belitz, H.D. and Grosch, W. (1999) Food Chemistry, Springer – Verlag, Berlin Heidelberg.
15. Damodaran, S. and Parot, A (editors), (1997) Food Proteins and their Applications. Marcol Dekker Inc.
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17. Diehl, J.F. (1995) Safety of Irradiated Foods Marcel Dekker Inc, New York.
18. Friberg, S.E. and Larsson, K. (editors) (1997) Food Emulsions. Marcel Dekker, New York.
19. Goldberg, I. (ed.) (1994) Functional Foods Chapman and Hall, Inc.
20. Gunaskekaran, S. (ed) (2001) Nondestructive Food Evaluation Marcel Dekker Inc, New York.
21. Tombs, M.P. (1991) Biotechnology in the Food Industry Prentice – Hall Inc, India.
22. O'Brien, L.O., Nabors and Gelardi, R.C. (1991) Alternative Sweeteners. marcel Dekker, New York.
23. Risch, S.J. and Hotchkiss, J.H. (ed.) (1991) Food Packaging Interactions II. ACS Symposium Series 473, American Chemical Society, Washington D.C.
24. Marwaha, S.S. and Arora, J.K. (2000) Food Processing: Biotechnological Applications Asiatech Publishers Inc, New Delhi.
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28. Charalambour, G. (1990) Flavours and Off-Flavours' 89, Elsevier Science Publisher Ltd., P.O. Box 211, 1000 AE Amsterdam, The Netherlands.
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30. FAO Food and Nutrition Paper: manual of Food Quality Control – Parts 14/1 (1979) to 14/8 (1986), FAO of the United Nations Rome.

Journals

1. Journal of Food Science Published by the Institute of Food Technologies, Chicago In. U.S.A.
2. Journal of Food Science and Technology published by Association of Food Scientists and Technologists (India) CFTRI – MYSORE.
3. Food technology published by the Institute of Food Technologists, Chicago Iu. U.S.A.

HFM205: SCIENCE AND TECHNOLOGY FOR RURAL DEVELOPMENT Credits 3

Appropriate Technology: Meaning of appropriate technology, affordable technology, need classification.

Science and Technology in Agriculture: Scientific methods of cultivation, post harvest Technology; Improved grain storage at domestic level, farm level and at large scales. Methods available for scientific food processing.

Waste Recycling: Waste, concept of waste recycling, classification, Agriculture, households, Industrial Waste, methods of recycling; Vermi Composting.

Science and Technology in the Field of Nutrition: Science and Technology as applied to the Field of nutrition; Low cost, indigenous, fast and convenience foods.

Food Preservation: Principles of Preservation, Methods of Preservation using sugar, jam, jelly, marmalade. Chemical preservatives; squash, cordial, crush and syrup, spices, salt and oil-pickles, sauses, ketchups.

Fuel Management: Use of fuel wood; Present practices and problems Smokeless Chulah**,** Use of 'alternate' non-conventional sources of energy including wind and wave.

Biogas: Biogas-Scope and principles Models promoting the use of biogas.

Use of Solar Energy: Scope for and advantages of the use of solar energy**,** Solar energy devices; different modes

Agencies involved in promoting Science and Technology for Rural Development: Institutions involved; DST, CAPA RT, Indian Renewable Energy**,** Development Agency (IREDA) Ministry of Non-conventional Energy Sources.

References

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4. Chawla, O.P. Advances in Bio-gas Technology, Indian Council of Agricultural Research, New Delhi, 1989.
5. Garg, H.P. and Prakash, J. Solar Energy – Fundamentals and Applications, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
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7. Swaminathan, M., Advanced Textbook on Food and Nutrition, The Bangalore Printing and Publishing Co. Ltd., 2nd Edition, 1985.
8. Department of Science and Technology, Models for Rural Application, Progressive Printers, New Delhi, 1995.
9. Prescott, B.C. and Proctor, B. K. Food Technology, McGraw Hill Book Company, New York, 1987.
10. Vinkata Ramana. P. Rural and Renewable Energy: Perspectives from Developing Countries, Tata Energy Research Institute, New Delhi.
11. Qasim, S.Z. Science and Quality of Life, The off setters, New Delhi, 1992.

12. Centre of Science for Village, Wardha – Science and Technology for Women (A Compendium of Technologies), Department of Science and Technology, New Delhi, 1989.
13. Siddappa, L. S. and Tandon, G. M. Preservation of Fruits and Vegetables, ICAR, New Delhi, 1984. Prescott, S.C. and Proctor, B. K., Food Technology, McGraw Hill Book Company, New York, 1987.

Journals

a. Science for Villages.
b. Yojana
c. CAPART Press Clippings.
d. Khadi Gramodyog
e. Construction on Rural Technology

Code: HFM206M: COMPUTER APPLICATION **Credits 3**

Overview of a computer system: Introduction; Software and hardware; Block diagram of computer; CPU, I/O and memory. Basics of operating systems MS-DOS and WINDOWS. Basic use of MS-WORD, MS-EXCEL and Power point packages.

Statistical Analysis using MS-EXCEL /R /SPSS software with special emphasis to the following topics:

1. Diagrammatic, graphical and Tabular representation of data
2. Measures of central tendency and dispersion
3. Linear regression and correlation
4. t-test
5. χ^2-test
6. ANOVA

IIIrd Semester

Code: HFM301: PILOT SURVEY FOR DISSERTATION AND SYNOPSIS FORMULATION AND SEMINAR **Credits 3**

For this paper students are required to do the following:

Conduct pilot survey for collecting the data and formulate the synopsis for the dissertation.

Deliver a seminar for their above work

Code: HFM302: EXPERIMENTAL FOODS **Credits 3**

Introduction to Food Science: Evolution of the Food Industry and Allied Industries. Development of Food Science as a discipline, Colloidal state, stabilization of colloidal systems, Rheology of food dispersions, Gels; Structure, formation, strength, types of permanence, Emulsions; Formation, stability, surfactants and emulsifiers, Foams; Structure, formation and stabilization.

Polysaccharides, Sugar and Sweeteners: Starch; Structure, gelatinization, methods for following gelatinizaiton changes, Characteristics of some food starches, Effects of ingredients and conditions on gelatinization, Modified food starches, Non-starch Polysaccharides; Cellulose, hemicelluloses, pectins, gums, animal polysaccharides, Sugars and Sweeteners; Sugars, syrups, sugar alcohols, potent sweeteners, sugar products, Sweetener chemistry related to usage in food products; Structural relationships to sweetness perceptions, hydrolytic reactions, solubility and crystallization, hygroscopicity, colligative properties, textural contributions, fermentation, non-enzymatic browning.

Cereals and Cereal Products: Cereal grains: Structure and composition, Cereal products, Flours and flour quality**,** Extruded foods, breakfast cereals, wheat germ, bulgar, puffed and flaked cereals.

Fats, Oils and related Products: Sources, composition, effects of composition on fat properties, Functional properties of fat and use in food preparations, Fat substitutes, Fat deterioration and antioxidants, Radiolysis, Inter-esterification of fats.

Proteins: Classification, composition, denaturation, non-enzymtic browning,

Enzymes: Nature of enzymes, stability and action. Proteolytic enzymes, oxidases, lipases, enzymes decomposing carbohydrates and applications. Immobilised enzymes duration of protein

Milk and Milk Products: Composition. Physical and functional properties. Denaturation, Effects of processing and storage, Dairy products; cultured milk, yogurt, butter whey, cheese, concentrated and dried products, frozen desserts, dairy product substitutes.

Meat and Poultry: Muscle composition Characteristics and structure, Post mortem changes, Processing, preservation and their effects. Heat-induced changes in meat, Variables in meat preparation, Tenderizers, meat Products.

Eggs: Structure and Composition, changes during storage, Functional properties of eggs, use in cookery, Egg processing, Low cholesterol egg substitutes.

Fish and Sea Food: Types and composition Storage and changes during storage, changes during processing, By-products and newer products.

Pulses and Legumes: Structure, composition, Processing, Toxic constituents.

Nuts and Oilseeds: Composition, oil extraction and by products.

Protein Concentrates, hydrolysates and textured vegetable proteins, milk substitutes.

Fruits and Vegetables: Plant anatomy, gross composition, structural features and activities of living systems, enzymes in fruits and vegetables. Flavour constituents. Plant phenolics. Pigments, Post harvest changes, Texture of fruits and vegetables, Effects of storage, processing and preservation.

Spices and Condiments: Composition, flavouring extracts – natural and synthetic.

Processed Foods: Jams, Jellies, Squashes, Pickles.

Traditional Processed Products: Fermented Foods; cereal-based, pulse; based, fruit/vegetable – based, vinegar, pickles.

Leavened Products: Leavening agents, Biologically leavened and chemically leavened products, Batters and dough.

Salt and substitutes.

PRACTICALS

HFM307: EXPERIMENTAL FOODS **Credits 2**

1. Effect of solutes on boiling point and freezing point of water.
2. Effect of types of water on characteristics of cooked vegetables, pulses and cereals.
3. **Sugar and Jaggery Cookery:** Relative sweetness, solubility and sizes of sugars, stages of sugar cookery, caramelization, crystallization, factors affecting crystal formation.
4. **Starches, Vegetable, Gums and Cereals:** Dextrinization gelatnization, retrogradation, thickening power. Factors affecting gels. Gluten formation and factors affecting gluten formation.
5. **James and Jellies:** Pectin content of fruits, role of acid, pectin and sugar in jam and jelly formation. Use of gums and emulsifiers/stabilizers.
6. **Fat and Oils:** Flash point, melting point and smoking point. Role of fats and oils in cookery as: shortening agent, frying medium. Factors affecting fat absorption. Fat crystals. Plasticity of fats. Permanent and semi-permanent emulsions.
7. **Milk and Milk Products:** Scalding, denaturation. Effect of acid, salt, alkali, sugar, heat, enzymes, polyphenols on milk. Khoa, curd, paneer, cheese (ripened and un-ripened).
8. **Egg:** Structure, assessing egg quality. Use of egg in cookery: Emulsions, air incorporation, thickening, binding, gelling. Method of egg cookery and effect of heat. Egg white foams and factors affecting foams.
9. **Pulses:** Effect of various cooking and processing methods on various characteristics, functional properties of pulses and their products.

10. **Meat and Poultry:** Methods affecting tenderness of meat, effect of various methods of cooking and ingredients on colour, volume, texture, flavour, aroma and water holding capacity.
11. **Fish and Sea Food:** Effect of different cooking methods on various fish and sea foods.
12. **Gelatin:** Gelatin, gel strength and factors affecting gelation. Ability to foam.
13. **Fruits and Vegetables:** Pigments: Effects of cooking, metal ions, pH. Effect of various coking processes on different characteristics of vegetables. Prevention of enzymatic browning.
14. **Leavened Products:** Fermentation – Use of micro-organisms (lactic acid, yeast), steam as an agent, egg as an agent, chemical agents.
15. **Beverages:** Factors affecting quality of beverages.
16. **Frozen Desserts:** Factors affecting ice crystal formation. Quality characteristics of frozen desserts.

References:

1. Charley, H. (1982): Food Science (2nd edition), John Wiley & Sons, New York.
2. Potter, N. and Hotchkiss, J.H. (1996): Food Science, Fifth edition, CBS Publishers and Distributors, New Delhi.
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8. Parihar, P., Agrwal, R., Jain, D.K. and Mandhyan, B.L. (1977): Status Report on Dehydration of Eggs, PHT/CAE/Publisher.
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10. Tindall, H.D. (1983): Vegetables in the Tropics, MacMillan, Press, London.
11. Julians, B.O. (Ed.) (1985): Rice Chemistry and Technology, (2nd edition), American Association of Cereal Chemists, St. Paul Mimesota, USA.
12. Bowers, J. (1992): Food Theory and Applications, (2nd edition), MacMillan Publishing Co., New York.
13. Peckham, G. and Freeland – Graves, G.H. (1979): Foundations of Food Preparation.
14. Becker, P. (1965): Emulsions: Theory and Practice, Reinhold, New York.

Journals

1. Journal of Food Science.
2. Advances in Food Research
3. Journal of Food Science and Technology
4. Journal of Agricultural and Food Chemistry.
5. Cereal Science
6. Journal of Dairy Sciences.
7. Journal of the Oil Chemists Society.

Code: HFM303: ADVANCED NUTRITION – II **Credits 3**

Physiology of hunger and Satiety: Role of central nervous system, gastric contractions, intestinal absorption, glucostatic regulation.

Nutrient requirements: The basis upon which nutrient recommendations are made. Difference between requirements recommended allowances and desired intake.

Recommended intake for proteins, calories, fat, carbohydrates, vitamins, minerals and water, Traces elements in human nutrition, Nutrient interrelationships, Protein energy interrelationships, Amino acid interrelationships, "Amino acid" and "Vitamin" interrelationships, vitamin and mineral interrelationship, mineral, vitamin, hormones, enzymes interrelationships, Nutritional adaptations, Nutrition and natural resistance to infection and acquired immunity, Inborn errors of metabolism, The use of radio isotopes in the study of human nutrition.

PRACTICALS

HFM308: ADVANCED NUTRITION – II **(Credits 2)**

1. Calculation of nutrient requirements of individuals and population groups.
2. Factors to be taken into consideration for determination of recommended allowances.
3. Study of Dietary Standards.
4. Diagnosis of nutritional deficiencies and their prevention.
5. Estimation of Protein Quality using different methods PER, B.V., N.P.U., NDP – Cal%.
6. Estimation of energy value of foodstuffs using bomb calorimeter.
7. Estimation of Energy Requirements; BMR, Energy expenditure on physical activities, Factorial approach
8. Balance studies; Nitrogen balance

References:

1. Mitchell: Comparative nutrition of man and domestic animal, 1. I, II. 1964.
2. Alabnese: New method of nutritional Biochemistry, Vol. II, 1965.
3. Annual Reviews of Nutrition. Annual Review Inc, California, USA.
4. Shils, M.E.; Olson, J.; Shike, M. and Roos, C. (1998): Modern Nutrition in Health and Disease. 9th edition. Williams and Williams. A Beverly Co. London.
5. Bodwell, C.E. and Erdman, J.W. (1988) Nutrient Interactions. Marcel Dekker Inc. New York.
6. World Reviews of Nutrition and Dietetics.
7. European Journal of Clinical Nutrition.
8. International Journal of Vitamin and Nutrition Research.
9. International Journal of Food Science and Nutrition.
10. Nutrition Research
11. Ann Nutr Metab

Code:HFM304: NUTRITIONAL EPIDEMIOLOGY **Credits 3**

Introduction to Epidemiology and Branches of Epidemiology: Types of Epidemiology
Epidemiological Information: Collecting epidemiological data, Secondary Routine
Patterns of Disease: Descriptive Epidemiology, Cross sectional analysis, Prevalence and incidence, risk factors, risks and odds, Relative and Attributable risks**,** Principles of Nutritional Epidemiology.
Measurement Issues: Measurement of disease, Occurrence and Measures of association, Exposure and Outcome, Assessment of Food Consumption, Intake and validation of Assessment, Biochemical Markers of nutrient intake and nutritional status, Socio-demographic and psycho social variables, Anthropometric measurements, Design and planning of Nutritional Epidemiological studies, Assessing, Applying and Evaluating Epidemiological Studies, Discussion of selected case studies, Nutritional assessment as a tool for improving the quality of life of various segments of the population including hospitalized patients, Current methodologies of assessment of nutritional status, their interpretation and comparative applications of the following; Food consumption, Anthropometry, Clinical and Laboratory, Rapid Assessment & **PRA**, Functional indicators such as grip strength,

respiratory fitness. Harvard Step test, Squatting test, Nutritional Surveillance; Basic concepts, uses and setting up of surveillance systems, Monitoring and Evaluation

References

1. Anisa Basheer (1995): Environmental Epidemology, Rawat Publications, Jaipur
2. Margetts, B.M. and Nelson, M. (1998): Design Concepts in Nutritional Epidemiology, Oxford, New York.
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5. Farmer, R. Miller, D. and Lawerson, R. (1996): Lecture Notes on Epidemology and Public
6. Health Medicine, Oxford, New York.
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12. HRSA/MCHB/UIC (1998): Analytic Methods in Maternal and Child Health, Division of Science, Education and Analysis, Maternal and Child Health Bureau, Health Resources and Services Administration, Editors Hardler, A, Roserberg, D., Monahan, C., Kennelly, J.
13. Kiely, M. (ed.) (1991): Reproductive and Perinatal Epidemology, CRC Press.
14. UK Nutritional Epidemiology Group (1993): Diet and Cancer: A review of the epidemology literature. The Nutrition Society, London.
15. Dunn, G (1989) Design and analysis of reliability studies. Edward Arnold, London.
16. Dwyer, J.H. Feinleib, M, Lipert, P., Hoffmeister, H (ed) (1992) statistical Models for Longitudinal Studies of Health. Oxford University Press, Oxford.
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19. Kok, F.J. and Van't Veer, P. (ed) (1991): Biomarkers of ?Dietary Exposure. Smith-Gordon, London.
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22. Jelliffe, D.B. and Jelliffe, E.F.P. (1989): Community Nutritional Assessment, Oxford University Press.
23. Beghin, I., Cap, M. and Dujardan, B. (1988): A Guide to Nutritional Status Assessment, WHO, Geneva.
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25. Mason, J.B., Habich, J.P., Tabatabai, H. and Valverde, V. (1984): Nutritional Surveillance, WHO.
26. Lee, R.D. and Nieman, D.C. (1993): Nutritional Assessment, Brown and Benchmark Publishers.

27. Sauberlich, H.E. (Ed.) (1999): Laboratory Tests for the Assessment of Nutrition Status, CRC Press.
28. Cameron, N. (1984): Measures of Human growth, Sheridan House Inc. New York.

Code: HFM305: COMMUNITY NUTRITION **Credits 3**

Concept of community nutrition: Relationship between health and nutrition, role of public nutritionists in the health care delivery.

Primary Health Care of the Community: National Health Care Delivery System**,** Determinants of Health Status**,** Indicators of Health

Food and Nutrition Security: Nutritional Status; Determinants of nutritional status of individual and populations, Nutrition and Non-nutritional indicators; socio-cultural, biologic, environmental and economic.

Major Nutritional Problems: Etiology, prevalence, clinical manifestations, preventive and therapeutic measures; Macro and micro nutrient deficiencies**,** Other nutritional problems like lathyrism, dropsy, aflatoxicosis, alcoholism and fluorosis/Overweight, obesity and chronic degenerative diseases.

National Food and Nutrition Policy, Plan of Action and Programmes: Health-based interventions, Food-based interventions, including fortification and genetic improvement of foods, supplementary feeding, Nutrition education for behaviour change.

1. Owen, A.Y. and Frankle, R.T. (1986): Nutrition in the Community, The Art of Delivering Services, 2nd Edition, Times Mirror/Mosby.
2. Park, K. (2000: Park's Textbook of Preventive and Social Medicine, 18th Edition, M/s Banarasidas Bhanot, Jabalpur.
3. State of the World's Children, UNICEF.
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5. Bamji, M.S., Rao, P.N. Reddy, V. (Eds.) (1996): Textbook of Human Nutrition; Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi
6. Gopalan, C. and Kaur, S. (Eds.) (1989): Women and Nutrition in India, Nutrition Foundation of India.
7. Gopalan, C. and Kaur, S. (Eds.) (1993): Towards Better Nutrition, Problems and Policies, Nutrition Foundation of India.
8. Gopalan, C. (Ed.) (1987): Combating Undernutrition – Basic Issues and Practical Approaches, Nutrition Foundation of India.
9. National Plan of Action on Nutrition (1995): Food and Nutrition Board, Dept. of WCD, Govt. of India.
10. National Nutrition Policy (1993): Dept. of WCD, Govt. of India.
11. World Health Organization (1998): World Health Report: Life in the 21st Century, Report of the Director General, WHO, Geneva, Switzerland.

HFM306M: DEVELOPMENT PROJECT MANAGEMENT AND SEMINAR **Credits 3**

Basic concept of project planning: ***Basic concepts: Need, problem, project feasibility, planning, project formulation, forecasting, appraisal, PRA, importance and objectives of project formulation; project development cycle and its stages, project classification, Project Identification: Identification of project opportunities, government policy, regulations, incentives and restrictions; methods and techniques of project identification, prioritisation of projects with people's participation; pre-feasibility study, Project formulation; Feasibility study and opportunity study; techno-economic analysis; project design and network analysis; input analysis, financial analysis; social cost-benefit analysis, Project Appraisal; Comprehensive appraisal of the key components of the project; project appraisal techniques; decision matrix, systems analysis, urgency and risk analysis, break even point analysis, pay back period analysis, rate of return, MPV profitability and I.R.R. analysis, risk analysis and social cost benefit analysis, Project Format; Common format of a project proposal - basic and supportive information required for a project; rules governing the preparation of project proposal writing up a project proposal.***

Related Experiences

1. Getting familiar with the proposal formats of different funding agencies.
2. Need identification and planning of a project for funding by appropriate agencies and developing project proposal.

References

1. Bhargava, B.S. et a!. (1977): Project Identification, Formulation and Appraisal, Metropolitan Book House, New Delhi.
2. Chandra, P. (1992): Project Preparation, Appraisal, Budgeting and Implementation, Tata McGraw Hill, New Delhi.
3. Emaberger et a!. (1990): Case Studies of Project Sustainabiity, Implications for Policy and Operations from Asian Experience, World Bank.
4. Goel, E.B. (1991): Project Management, Tata McGraw Hill, New Delhi.
5. Gupta, R.C. (1990): Management Information Systems, CDS Publishers, New Delhi.
6. Little I.M.D. Mirriess, J.A. (1974): Project Appraisal and Planning for Development Countries, Educational Books Company, New Delhi.
7. Mukherjee, A. (1991): Methodology and Database for Centralised Planning with Special Reference to Decentralised Planning in India, Vol. I, II & III.

IVth Semester

HFM402: THERAPEUTIC NUTRITION AND BIOCHEMICAL CORRELATES OF NUTRITIONAL THERAPY **Credits 3**

PART – A – THERAPEUTIC NUTRITION

Nutritional screening and assessment of nutritional status of hospitalized and outdoor patients: Identification of high-risk patients, Assessment of patient needs based on interpretation of patient data-clinical, biochemical, biophysical, personal etc.

Newer trends in delivery of nutritional care and dietary counselling.

Diet, nutrient and drug interaction: Effect of drugs on ingestion, digestion, absorption and metabolism of nutrients, Effect of food, nutrients and nutritional status on drug dosage and efficacy.

Nutritional support: Recent advances in techniques and feeding substrates.

Etiopathophysiology, metabolic and clinical aberrations, complications, prevention and recent advances in medical nutritional management of: Weight imbalances**,** Cardio vascular disorders**,** Diabetes mellitus and other metabolic disorders**,** GI Tract Disorders**,** Liver and gall bladder, Pancreatic disorders**,** Renal disorders**,** Stress and trauma**,** Cancer**,**

Neurological disorders**,** Musculo-skeletal disorders**,** Immuno-deficiency disorders**,** Genetic disorders**,** Infections, Respiratory problems

Childhood problems/disorders including inborn errors of metabolism and their nutritional management.

PART – B – BIOCHEMICAL CORRELATES OF NUTRITIONAL THERAPY

Biochemical tests used in nutrition: Merits and demands of various methods, Organ function tests; Organ function tests of liver, kidney, thyroid, gastric, pancreas, Nutrition and Cancer; Effects of cancer on nutritional requirements, Effects of food on incidence of certain cancers, Carcinogenic foods, Foods that prevent cancer, Nutritional management of non-nutritional conditions; Alcohol related diseases, Diseases due in tobacco chewing, betel leaf chewing, paan masala, etc., Dental diseases, Role of nutrition in skin and hair care: Cosmetic effects of diet; Cellulite, Allergies, Anti aging foods, Foods as cosmetic agents, Eating disorders; Anorexia nervosa, bulimia nervosa, Food and Endorphins; Alteration of mental states by food, Sepsis and trauma; Metabolic alterations in injury, sepsis, Protein metabolism in sepsis, cytokines, nutritional support in trauma and sepsis, AIDS.

PRACTICALS

HFM404: THERAPEUTIC NUTRITION AND BIOCHEMICAL CORRELATES OF NUTRITIONAL THERAPY **(Credits 2)**

PART A – THERAPEUTIC NUTRITION

1. Collection and storage of biological samples for clinical investigations
2. Market survey of commercial nutritional supplements and nutritional support substrates
3. Commonly used tests for diagnosis of various diseases; Interpretation of patient data and diagnostic tests and drawing up of patient diet prescription, using a case study approach, Follow up; acceptability of diet prescription, compliance, discharge diet plan.
4. Preparation of diet counselling aids for common disorders.
5. Planning and preparation of diets for patients with common multiple disorders and complications and discharge diet plans.

PART – B – BIOCHEMICAL CORRELATES

1. Diet planning for patients having multiple diseases
2. Case studies of selected patient/s in a local hospital.
3. Visit to the in-patient care section of a local hospital and evaluation of the kitchen in the hospital**.**

References

1. Mahan, L.K. and Escott-Stump, S. (2000): Krause's Food Nutrition and Diet Therapy, 10th Edition, W.B. Saunders Ltd.
2. Shils, M.E., Olson, J.A., Shike, M. and Ross, A.C. (1999): Modem Nutrition in Health and Disease, 9th Edition, Williams and Wilkins.
3. Escott-Stump, S. (1998): Nutrition and Diagnosis Related Care, 4th Edition, Williams and Wilkinson
4. Garrow, J.S., James, W.P.T. and Ralph, A. (2000): Human Nutrition and Diabetics, 10th Edition, Churchill Livingstone.
5. Williams, S.R. (1993): Nutrition and Diet Therapy, 7th Editioin, Times Mirror/Mosby College Publication.
6. Davis, J. and Sherer, K. (1994): Applied Nutrition and Diet Therapy for Nurses, 2nd Edition, W.B. Saunders Co.
7. Walker, W.A. and Watkins, J.B. (Ed.) (1985): Nutrition in Pediatrics, Boston, Little Brown & Co.

8. Guyton, A.C. and Hall, J.E. (1999): Textbook of Medical Physiology, 9th Edition, W.B. Saunders Co.
9. Ritchie, A.C. (1990): Boyd's Textbook of Poathology, 9th Edition, Lea and Febiger, Philadelphia.
10. Fauci, S.A. et al (1998): Harrison's Principles of Internal Medicine, 14th Edition, McGraw Hill.
11. World Cancer Research Fund (1997): Food Nutrition and the Prevention of Cancer – A Global perspective, Washington E.D. WCRF

Journals and Other Relevance Series

1. Nutrition Update Series
2. World Review of Nutrition and Dietetics
3. Journal of the American Dietetic Association
4. American Journal of Clinical Nutrition
5. European Journal of Clinical Nutrition
6. Nutrition Reviews

M. Sc. MATHEMATCIS
Department of Mathematics
Banaras Hindu University

Semesterwise distribution of Courses and Credits

Semester –I		
Course Code	**Title**	**Credits**
MTM 101	Algebra-I	4
MTM 102	Real Analysis-I	4
MTM 103	Topology	4
MTM 104	Differential Geometry of Manifolds-I	4
MTM 105	Set Theory & Complex Analysis	4
MTM 106M #	*Minor Elective*: Mathematical Methods (for students of other PG programmes) *Minor Elective* (for Mathematics students)	3
	Total	**23**
Semester –II		
MTM 201	Algebra-II	4
MTM 202	Real Analysis-II	4
MTM 203	Analytic Dynamics	4
MTM 204	Differential Geometry of Manifolds-II	4
MTM 205	Theory of Optimization	4
MTM 206M #	*Minor Elective*: Mathematical Modeling (for students of other PG programmes) *Minor Elective* (for Mathematics students)	3
	Total	**23**
Semester –III		
MTM 301	Hydrodynamics	4
MTM 302	Normed Linear Spaces & Theory of Integration	4
MTM 303	Numerical Analysis	4
	Major Elective (Any two of following courses , each of 4 credits : MTM 304 - MTM 309)	8
MTM 304	Discrete Mathematics	
MTM 305	Operations Research	
MTM 306	Gravitation	
MTM 307	Structures on Differentiable Manifolds - I	
MTM 308	Advanced Topology	
MTM 309	Integral Equations	
MTM 310M #	*Minor Elective*: Computational Bioinformatics for students of other PG programmes) *Minor Elective* (for Mathematics students)	3
	Total	**23**
Semester –IV		
MTM 401	Functional Analysis	4
MTM 402	Partial Differential Equations	4
	Major Elective (Any two of following courses , each of 4 credits : MTM 403 - MTM 409)	8
MTM 403	Fluid Mechanics	
MTM 404	Numerical Solution of Partial Differential Equations	
MTM 405	Structures on Differentiable Manifolds-II *	
MTM 406	Algorithms and Data Structures	
MTM 407	Wavelets	
MTM 408	Cosmology **	
MTM 409	Category Theory.	
	Minor Elective (Any one of following courses , each of 3 credits : MTM 410 - MTM 416)	3
MTM 410	Fuzzy Sets and Applications	
MTM 411	Financial Mathematics	
MTM 412	Number Theory and Cryptography	
MTM 413	Operator Theory	
MTM 414	Bio-Mechanics	
MTM 415	Module Theory	
MTM 416	Advanced Graph Theory	

MTM 417	**Project**	**6**
	Total	**25**
	Grand Total	**94**

* For the course MTM 405, the Pre-requisite course is MTM 307

** For the course MTM 408, the Pre-requisite course is MTM 306

*** More Major Elective and Minor Elective courses can be added subject to availability of subject expert.

M.Sc. Mathematics students will opt 3 Minor Elective Courses (each of 3 credits) offered by other PG Programmes of the Faculty.

SEMESTER I

MTM 101 Algebra-I Credits : 4

The class equation, Cauchy`s theorem, Sylow *p*-subgroups, Direct product of groups. Structure theorem for finitely generated abelian groups. Normal and subnormal series. Composition series, Jordan-Holder theorem. Solvable groups. Insolvability of S_n for $n \geq 5$.

Extension fields. Finite, algebraic, and transcendental extensions. Splitting fields. Simple and normal extensions. Perfect fields. Primitive elements. Algebraically closed fields. Automorphisms of extensions. Galois extensions.

Fundamental theorem of Galois theory. Galois group over the rationals.

References:

1. I. N. Herstein, *Topics in Algebra*, Wiley Eastern, 1975.
2. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, *Basic Abstract Algebra* (2nd Edition), Cambridge University Press, Indian Edition 1977.
3. Ramji Lal, *Algebra,* Vol.1, Shail Publications, Allahabad 2001.
4. Vivek Sahai and Vikas Bist, *Algebra*, Narosa Publishing House 1999.
5. D. S. Malik, J. N. Mordeson, and M. K. Sen, *Fundamentals of Abstract Algebra*, McGraw-Hill International Edition, 1997.

MTM 102 Real Analysis-I Credits : 4

Definition and existence of Riemann-Stieltjes integral, Conditions for R-S integrability. Properties of the R-S integral, R-S integrability of functions of a function.

Series of arbitrary terms. Convergence, divergence and oscillation, Abel's and Dirichilet's tests. Multiplication of series. Rearrangements of terms of a series, Riemann's theorem.

Sequences and series of functions, pointwise and uniform convergence, Cauchy's criterion for uniform convergence. Weierstrass M-test, Abel's and Dirichlet's tests for uniform convergence, uniform convergence and continuity, uniform convergence and Riemann-Stieltjies integration, uniform convergence and differentiation. Weierstrass approximation theorem. Power series. Uniqueness theorem for power series, Abel's and Tauber's theorems.

References:

1. Walter Rudin, *Principle of Mathematical Analysis* (3rd edition) McGraw-Hill Kogakusha, 1976, International Student Edition.
2. K. Knopp, *Theory and Application of Infinite Series*.
3. T. M. Apostol, *Mathematical Analysis*, Narosa Publishing House, New Delhi, 1985.

MTM 103 Topology Credits : 4

Definition and examples of topological spaces. Closed sets. Closure. Dense sets. neighborhoods, interior, exterior, and boundary. Accumulation points and derived sets. Bases and sub-bases. Subspaces and relative topology.

Alternative methods of defining a topology in terms of Kuratowski closure operator and neighborhood systems.

Continuous functions and homeomorphism. First and second countable space. Lindelöf spaces. Separable spaces.

The separation axioms T_0, T_1, T_2, $T_{3½}$, T_4; their characterizations and basic properties. Urysohn's lemma. Tietze extension theorem.

Compactness. Basic properties of compactness. Compactness and finite intersection property. Sequential, countable, and B-W compactness. Local compactness. One-point compactification.

Connected spaces and their basic properties. Connectedness of the real line. Components. Locally connected spaces.

Tychonoff product topology in terms of standard sub-base and its characterizations.Product topology and separation axioms, connected-ness, and compactness (incl. the Tychonoff's theorem), product spaces.

Nets and filters, their convergence, and interrelation. Hausdorffness and compactness in terms of net/filter convergence.

References:

1. J. L. Kelley, *General Topology*, Van Nostrand, 1995.
2. K. D. Joshi, *Introduction to General Topology*, Wiley Eastern, 1983.
3. James R. Munkres, *Topology,* 2nd Edition, Pearson International, 2000.
4. J. Dugundji, *Topology*, Prentice-Hall of India, 1966.
5. George F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, 1963.
6. N. Bourbaki, *General Topology,* Part I, Addison-Wesley, 1966.

7. S. Willard, *General Topology,* Addison-Wesley, 1970.
8. S.W. Davis *Topology*, Tata McGraw Hill, 2006

MTM 104 Differential Geometry of Manifolds-I Credits : 4

Tensor of the type(r,s). Definition and examples of differentiable manifolds. Tangent spaces. Jacobian map. One parameter group of transformations. Lie derivatives. Immersion and imbeddings. Distributions.

Riemannian manifolds. Riemannian Connection. Curvature tensors. Sectional curvature. Schur's theorem. Geodesics. Projective curvature tensor. Conformal curvature tensor. Semi-symmetric connections.

Submanifolds and Hypersurfaces. Normals. Gauss's formula. Weingarten equations. Lines of curvature. Generalized Gauss and Mainardi-Codazzi equations.

References:

1. R. S. Mishra, *A Course in Tensors with Applications to Riemanian Geometry*, Pothishala, Allahabad, 1965.
2. Y. Matsushima, *Differentiable Manifolds*, Marcel Dekker, 1972.
3. B. B. Sinha, *An Introduction to Modern Differential Geometry*, Kalyani Prakashan, New Delhi, 1982.
4. Y. Talpiert, Differential *Geometry with applications to Mechanics and Physics*, Marcel Dekkar Inc. 2001.
5. N.J. Hicks, *Notes on Differential Geometry*, D. Van Nostrand Inc. , 1965.

MTM 105 Set Theory & Complex Analysis Credits : 4

Set Theory: Countable and uncountable sets, Cardinal numbers, Schroeder- Bernstien theorem, POSET, Zorn`s lemma and its application.

Complex Analysis: Complex Integration. Cauchy-Goursat Theorem. Cauchy's integral formula. Higher order derivatives. Morera's theorem. Cauchy's inequality and Liouville's theorem. The fundamental theorem of algebra. Taylor's Theorem. Maximum modulus Principle, Schwarz lemma.

Laurent's Series. Isolated singularities. Casporati-Weierstress theorem. Meromorphic functions. The argument principle. Rouche's theorem.

Residues. Cauchy's residue theorem. Evaluation of integrals. Branches of many valued functions with special reference to arg Z, Log Z, and Z^a.

Analytic continuation.

References:

1. K. Knopp, *Theory of Functions*, Vol. 1.
2. E. C. Titchmarsh, *The Theory of Functions*, Oxford University Press.
3. J. B. Conway, *Functions of One Complex Variable*, Narosa Publishing House, 1980.
4. E. T. Copson, *Complex Variables*, Oxford University Press.
5. L. V. Ahlfors, *Complex Analysis*, McGraw-Hill, 1977.
6. D. Sarason, *Complex Function Theory*, Hindustan Book Agency, Delhi, 1994.
7. P. Suppes, *Axiomatic Set Theory*, Van Nostrand, 1960.
8. P.R. Halmos, *Naive Set Theory*, Van Nostrand, 1960.
9. K.K. Jha, *Advanced Set Theory & Fundamentals of Mathematics*, P.C. Dwadesh Shreni & Co., Aligarh, 1993.

MTM 106M Mathematical Methods Credits : 3

The objective of the course is to introduce the mathematical methods to the PG students of Physical sciences for the possible requirements in the modeling of the problems in their respective discipline of studies.

Integral Transforms.

Z-Transforms.

Fourier Series.

Matrix Coputations.

Chebyshev Polynomials

Complex Integration.

***References*:**

1. G.B. Thomas, R.L.Finney, M.D.Weir, Calculus and Analytic Geometry, Pearson Education Ltd, 2003.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 1999.

SEMESTER - II

MTM 201 Algebra–II Credits : 4

Modules, submodules, Quotient Modules, Isomorphism theorems. Cyclic modules, simple modules and semi-simple modules and rings Schur's lemma. Free modules. Noetherian and Artinian modules and rings. Hilbert basis theorem .

Solution of polynomial equations by radicals. Insolvability of the general equation of degree ≥ 5 by radicals. Finite fields.

Canonical forms: Similarity of linear transformations. Invariant subspaces. Reduction to triangular forms. Nilpotent transformations. Index of nilpotency. Invariants of a nilpotent transformation. The primary decomposition theorem. Jordan blocks and Jordan form.

References:

1. I. N. Herstein, *Topics in Algebra*, Wiley Eastern, 1975.
2. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, *Basic Abstract Algebra* (2nd Edition), Cambridge University Press, 1997.
3. K. Hoffman and R. Kunze, *Linear Algebra*, 2nd Edition, Prentice Hall of India, 1971.
4. D. S. Malik, J. N. Mordeson, and M. K. Sen, *Fundamentals of Abstract Algebra,* McGraw-Hill International Edition, 1997.
5. Vivek Sahai and Vikas Bist, *Algebra*, Narosa Publishing House, 1999.
6. Ramji Lal, *Fundamentals in Abstract Algebra*, Chakra Prakashan, Allahabad, 1985.
7. J.S. Golan, Modules & the Structures of Rings, Marcl Dekkar. Inc.

MTM 202 Real Analysis-II Credits : 4

Functions of several variables. Derivative of functions in an open subset of $\Re^n$ into $\Re^m$ as a linear transformation. Chain rule. Partial derivatives. Taylor's theorem. Inverse function theorem. Implicit function theorem. Jacobians.

Measures and outer measures. Measure induced by an outer measure, Extension of a measure. Uniqueness of Extension, Completion of a measure. Lebesgue outer measure. Measurable sets. Non-Leesgue measurable sets. Regularity. Measurable functions. Borel and Lebesgue measurability.

Integration of non-negative functions. The general integral. Convergence theorems. Riemann and Lebesgue integrals.

References:

1. Walter Rudin, *Principle of Mathematical Analysis* (3rd edition) McGraw-Hill Kogakusha, International Student Edition, 1976.
2. H. L., Royden, *Real Analysis*, 4th Edition, Macmillan, 1993.
3. P. R. Halmos, *Measure Theory*, Van Nostrand, 1950.
4. G. de Barra, *Measure Theory and Integration*, Wiley Eastern, 1981.
5. E. Hewitt and K. Stromberg, *Real and Abstract Analysis*, Springer, 1969.
6. P. K. Jain and V. P. Gupta, *Lebesgue Measure and Integration*, New Age International, New Delhi, 2000.
7. R. G. Bartle, *The Elements of Integration*, John Wiley, 1966.

MTM 203 Analytic Dynamics Credits : 4

Rotation of a vector in two and three dimensional fixed frame of references. Kinetic energy and angular momentum of rigid body rotating about its fixed point.

Euler dynamic and geometrical equations of motion.

Generalized coordinates, momentum and force components. Lagrange equations of motion under finite forces, cyclic coordinates and conservation of energy.

Lagrangian approach to some known problems-motions of simple, double, spherical and cycloidal pendulums, motion of a particle in polar system, motion of a particle in a rotating plane, motion of a particle inside a paraboloid, motion of an insect crawling on a rod rotating about its one end, motion of masses hung by light strings passing over pulleys, motion of a sphere on the top of a fixed sphere and Euler dynamic equations.

Lagrange equations for constrained motion under finite forces. Lagrange equations of motion under impulses, motion of parallelogram about its centre and some of its particular cases.

Small oscillations for longitudinal and transverse vibrations.

Equations of motion in Hamiltonian approach and its applications on known problems as given above. Conservation of energy. Legendre dual transformations.

Hamilton principle and principle of least action. Hamilton-Jacobi equation of motion, Hamilton-Jacobi theorem and its verification on the motions of a projectile under gravity in two dimensions and motion of a particle describing a central orbit.

Phase space, canonical transformations, conditions of canonicality, cyclic relations, generating functions, invariance of elementary phase space, canonical transformations form a group and Liouville theorem.

Poisson brackets, Poisson first and second theorems, Poisson. Jacobi identity and invariance of Poisson bracket.

References:

1. A. S. Ramsay, *Dynamic* –Part II.
2. N. C. Rana and P.S. Joag, *Classical Mechanics*, Tata McGraw-Hill, 1991.
3. H. Goldstein, *Classical Mechanics*, Narosa, 1990.
4. J. L. Synge and B. A. Griffith, *Principles of Mechanics*, McGraw-Hill, 1991.
5. L. N. Hand and J. D. Finch, *Analytical Mechanics*, Cambridge University Press, 1998.
6. Naveen Kumar, *Generalized Motion of Rigid Body*, Narosa, 2004.

MTM 204 Differential Geometry of Manifolds-II Credits : 4

Topological groups. Lie groups and Lie algebras. Product of two Lie groups. One parameter subgroups and exponential maps. Examples of Lie groups. Homomorphism and isomorphism. Lie transformation groups. General linear groups.

Principal fiber bundle. Linear frame bundle. Associated fiber bundle. Vector bundle. Tangent bundle. Induced bundle. Bundle homomorphisms. Exterior Algebra. Exterior derivative.

Almost complex and Almost contact structures. Nijenhuis tensor. Contravariant and covariant almost analytic vector fields in almost complex manifold. F-Connexion.

Almost complex and almost contact submanifolds and hypersurfaces.

References:

1. B. B. Sinha, *An Introduction to Modern Differential Geometry*, Kalyani Prakashan, New Delhi, 1982.
2. K. Yano and M. Kon, *Structure of Manifolds*, World Scientific, 1984.
3. Y. Matsushima , *Differential manifolds*, Marcel Dekkar, 1972.
4. K. Yano, *Differential Geometry of Complex and almost Complex Spaces*, Pergaman Press, 1965.
5. R. S. Mishra, *Structures on a Differentiable Manifold and Their Applications*, Chandrama Prakashan, Allahabad, 1984.

MTM 205 Theory of Optimization Credits : 4

Unconstrained Optimization: Introduction, Gradient methods, Conjugate Direction Methods, Newton's Method, Quasi Newton Method.

Linear Programming: Simplex Method, Duality and Non- simplex Methods.

Non- Linear Constrained Optimization: Introduction, Lagrange's multipliers, Kuhn- Tucker conditions, Convex Optimization.

Evolutionary Algorithms: Neural Networks: Introduction, Basic Hopfield Model, Delta Rule, Single Neuron Training, Backpropagation algorithm. Genetic Algorithm: Basic description, Simple real number algorithm.

References:

1. Edwin K. P. P. Chong, Stanislaw H. Zak, An Introduction to Optimization, Johan Welly & Sons Inc 2001.
2. M. C. Joshi & K.M. Moudgalya, Optimization Theory & Practice, Narosa Publ. New Delhi, 2004.
3. S.S.Rao, Engg. Optimization: Theory & Practice, New Age Intl. Pub. New Delhi, 2003.
4. Laurence, Fausett, Fundamentals of Neural Networks, Pearson education Ltd, 2005.
5. D.E. Goldberg, Genetic Algorithms in neural optimization and machine learning, Pearson Education. Ltd. 2004.

MTM 206M Mathematical Modeling Credits : 3

Simple situations requiring mathematical modeling, techniques of mathematical modeling, Classifications, Characteristics and limitations of mathematical models, Some simple illustrations.

Mathematical modeling through differential equations, linear growth and decay models, Non linear growth and decay models, Compartment models, Mathematical modeling in dynamics through ordinary differential equations of first order.

Mathematical models through difference equations, some simple models, Basic theory of linear difference equations with constant coefficients, Mathematical modeling through difference equations in economic and finance, Mathematical modeling through difference equations in population dynamic and genetics.

Situations that can be modeled through graphs. Mathematical models in terms of Directed graphs, Mathematical models in terms of signed graphs, Mathematical models in terms of weighted digraphs.

Mathematical modeling through linear programming, Linear programming models in forest management. Transportation and assignment models.

***References*:**

1. J. N. Kapur, *Mathematical Modeling*, Wiley Eastern.
2. D. N. Burghes, *Mathematical Modeling in the Social Management and Life Science*, Ellie Herwood and John Wiley.
3. F. Charlton, *Ordinary Differential and Difference Equations,* Van Nostrand.

SEMESTER -III

MTM 301 Hydrodynamics Credits : 4

Equation of continuity, Boundary surfaces, streamlines, Irrotational and rotational motions, Vortex lines, Euler's Equation of motion, Bernoulli's theorem, Impulsive actions. Motion in two-dimensions, Conjugate functions, Source, sink, doublets and their images, conformal mapping, Two-dimensional irrotational motion produced by the motion of circular cylinder in an infinite mass of liquid, Theorem of Blasius, Motion of a sphere through a liquid at rest at infinity. Liquid streaming past a fixed sphere, Equation of motion of a sphere.

Stress components in real fluid, Equilibrium equation in stress components, Transformation of stress components, Principal stress, Nature of strains, Transformation of rates of strain, Relationship between stress and rate of strain, Navier-Stokes equation of motion.

References:

1. W. H. Besant and A. S. Ramsey, *A Treatise on Hydrodynamics*, CBS Publishers and Distributors, Delhi, 1988.
2. S. W. Yuan, *Foundations of Fluid Dynamics*, Prentice-Hall of India, 1988.

MTM 302 Normed Linear Spaces and Theory of Integration Credits : 4

Normed linear spaces and Banach spaces. The L^P-space. Convex functions. Jensen's inequality. Holder and Minkowski inequalities. Completeness of L^P. Convergence in measure, Almost uniform convergence.

Signed measure. Hahn and Jordan decomposition theorems. Absolutely continuous and singular measures. Radon Nikodyn theorem. Labesgue decomposition. Riesz representation theorem. Extension theorem (carathedory). Lebesgue-Stieltjes integral.

Product measures. Fubini's theorem. Baire sets. Baire measure. Continuous functions with compact support. Regularity of measures on locally compact spaces. Integration of continuous functions with compact support. Reisz-Markoff theorem.

References:

1. H. L. Royden, *Real Analysis*, Macmillan, 4th Edition, 1993.
2. P. R. Halmos, *Measure Theory*, Van Nostrand, 1950.
3. S. K. Berberian, *Measure and Integration*, Wiley Eastern, 1981.
4. A. E. Taylor, *Introduction to Functional Analysis*, John Wiley, 1958.
5. G. de Barra, *Measure Theory and Integration*, Wiley Eastern, 1981.
6. R. G. Bartle, The Elements of Integration, John Wiley, 1966.
7. Inder K. Rana, *An Introduction to Measure and Integration*, Narosa Publishing House, 1997.

MTM 303 Numerical Analysis Credits : 4

Integral equations :Fredholm and Volterra equations of first and second types. Conversions of initial and boundary value problems into integral equations, numerical solutions of integral equations using Newton-Cotes, Lagrange`s linear interpolation and Chebyshev polynomial.

Matrix Computations: System of linear equations, Conditioning of Matrices, Matrix inversion method, Matrix factorization, Tridiagonal systems.

Numerical solutions of system of simultaneous first order differential equations and second order initial value problems (IVP) by Euler and Runge-Kutta (IV order) explicit methods.

Numerical solutions of second order boundary value problems (BVP) of first, second and third types by shooting method and finite difference methods.

Finite Element method: Introduction, Methods of approximation: Rayleigh-Ritz Method, Gelarkin Method and its application for solution of ordinary BVP.

References:

1. M. K. Jain, S. R. K. Iyenger and R. K. Jain, *Numerical Methods for Scientific and Engineering Computations*, New Age Publications, 2003.

2. M. K. Jain, *Numerical Solution of Differential Equations*, 2nd edition, Wiley-Eastern.
3. S. S. Sastry, *Introductory Methods of Numerical Analysis*,
4. D.V. Griffiths and I.M. Smith, *Numerical Methods for Engineers*, Oxford University Press, 1993.
5. C. F. Gerald and P. O. Wheatley, *Applied Numerical Analysis*, Addison- Wesley, 1998.
6. A. S. Gupta, *Text Book on Calculas of Variation*, Prentice-Hall of India, 2002.
7. Naveen Kumar, *An Elementary Course on Variational Problems in Calculus*, Narosa, 2004.

MAJOR ELECTIVE

(Any two of the following courses each having 3 Credits)

MTM 304 Discrete Mathematics Credits : 4

Graph Theory: Graphs, planar graphs and their properties. Trees. Euler's formula for connected planar graphs. Bipartite graphs. Spanning trees, Minimal spanning trees, Kruskal's Algorithms, Matrix representations of graph, Directed graphs, Weighted undirected graphs, Dijkstra's algorithm. Warshal's algorithm, Directed trees , Search trees, Traversals.

Theory of Computation: Finite automata, Deterministic and non deterministic finite automata , Moore and Mealy machines. Regular expressions.Grammars and Languages, Derivations, Language generated by a grammar. Regular Language and regular grammar.Regular and Context free grammar, Context sensitive grammars and Languages. Pumping Lemma, Kleene's theorem.

Turing Machines: Basic definitions. Turing machines as language acceptors. Universal Turing machines. Turing machine halting problem.

References:

1. F. Harary, *Graph Theory*, Narosa.
2. Narsingh Deo, *Graph Theory with Applications to Engineering and Computer Science*, Prentice-Hall of India.
3. W. T. Tutte, *Graph Theory*, Cambridge University Press, 2001
4. D. Kelly, *Automata and Formal Languages: An Introduction*, Prentice-Hall, 1995.
5. J. E. Hopcroft, R. Motwani, and J. D. Ullman, *Introduction to Automata, Languages, and Computation* (2nd edition), Pearson Edition, 2001.
6. P. Linz, *An Introduction to Formal Languages and Automata*, 3rd Edition,

MTM 305 Operations Research Credits : 4

Game Theory: Two person zero sum games, Games with mixed strategies, Graphical solution, Solution by linear programming.

Basic Concept of Multi Objective and Multi Level Optimization.

Integer Programming, Mixed Integer Programming. Linear Fractional Programming. Goal Programming. Sensitivity Analysis and System Reliability.

Geometric Programming: Constrained and Unconstrained Minimization Problems.

Dynamic Programming: Deterministic and Probabilistic dynamic programming.

Stochastic Programming: Stochastic Linear and Stochastic Non linear Programming.

Netwok Schedulig by PERT/CPM.

References:

1. F. S. Hiller and G. J. Leiberman, *Introduction to Operations Research* (6th Edition), McGraw-Hill International Edition, 1995.
2. G. Hadley, *Nonlinear and Dynamic Programming*, Addison Wesley.
3. H. A. Taha, *Operations Research –An Introduction*, Macmillan.
4. Kanti Swarup, P. K. Gupta and Man Mohan, *Operations Research*, Sultan Chand & Sons, New Delhi.
5. S. S. Rao, *Optimization Theory and Applications*, Wiley Eastern.
6. N. S. Kambo, *Mathematical Programming Techniques*, Affiliated East-West Press Pvt. Ltd., New Delhi.

MTM 306 Gravitation Credits : 4

Newtonian theory : Attraction and potential of rod, disc, spherical shell and sphere. Surface integral of normal attractions-Gauss theorem, Laplace and Poission equations. Work done by self attracting systems. Distribution for given potentials. Equipotential surfaces.

Einstein's Theory : Principles of equivalence and general covariance, Geodesic postulate. Newtonian approximation of general relativistic equations of motion. Heuristic derivation of Einstein's field equations,

Newtonian approximation of Einstein's field equations. Schwarzschild external solution. Planetary orbit. The three crucial tests. Energy momentum tensor of a perfect fluid. Schwarzschild internal solution.

References:

1. S. L. Loney, *An Elementary Treatise on Statics*, Kalyani Publishers-New Delhi, 1979.
2. A. S. Ramsey, *Newtonian Attraction,* Cambridge University Press, 1964.
3. A. S. Eddington, *The Mathematical Theory of Relativity,* Cambridge University Press, 1954.
4. R. Adler, M. Bazin and M. Schiffer, *Introduction to General Relativity*, McGraw-Hill, 1965.
5. S. R. Roy and Raj Bali, *Theory of Relativity*, Jaipur Publishing House, 1987.
6. J. V. Narlikar, *General Relativity and Cosmology*, Macmillan, 1978.

MTM 307 Structures on Differentiable Manifolds-I Credits : 4

Almost Hermite Manifolds : Definitions. Almost analytic vector fields, curvature tensor, linear connections, almost quaternion metric structure, submanifolds. F-connections.

Kahler Manifolds : Definition, curvature tensor, affine connections. Projective, conformal, concircular, conharmonic and Bochner curvature tensors. Contravariant almost analytic vectors, submanifolds, quaternion Kahler manifold.

Nearly Kahler Manifold : Definitions, certain properties, curvature identities, almost analytic vectors, immersions.

Almost Kahler Manifolds : Definitions, some properties, analytic vectors, conformal transformations, curvature identities, immersions.

Quasi-Kahler, Semi-Kahler Manifolds: Definitions, curvature identities, properties and immersion in a quasi-Kahler manifold.

References:

1. R.S. Mishra, *Structures on a Differentiable Manifold and Their Applications*, Chandrama Prakashan, Allahabad, 1984.
2. K. Yano, *Differential Geometry of Complex and Almost Complex Spaces*, Pergamon Press, 1965.

MTM 308 Advanced Topology Credits : 4

The Stone-Cech compactification. Paracompact spaces, their properties and characterizations. Metrizable spaces and Metrization theorems. Uniform spaces, Weak uniformity, Uniformizability. Completion of uniform spaces.

Function spaces. Point-wise and uniform convergence.The compact open Topology. The Stone-Weierstrass theorem.

References:

1 S. Willard, General Topology, Addison Wesley, 1970.
2 S.W.Davis, Topology, Tata McGraw Hill, 2006

MTM 309 Integral Equations Credits : 4

Classification. Modeling of problems as integral equations. Conversion of initial and boundary value problem into integral equations. Conversion of integral equations into differential equations. Volterra integral equations and their numerical solutions. Greens function for Fredholm Integral equations. Fredholm integral equations: Degenerate kernels, symmetric kernels. Fredholm Integral equation of second kind. Numerical Solution of Fredholm Integral equations.

Existence of the solutions: Basic fixed point theorems.

Integral equations and transformations: Fourier, Laplace and Hilbert transformation.

References:

1. Abdul J. Jerry, Introduction to Integral Equations with applications, Marcel Dekkar Inc. NY.
2. L.G.Chambers, Integral Equations: A short Course, Int. Text Book Company Ltd. 1976,
3. R. P. Kanwal, *Linear Integral Equations*.
4. Harry Hochsdedt, *Integral Equations*.
5. Murry R. Spiegal, *Laplace Transform* (SCHAUM Outline Series), McGraw-Hill.

MTM 310M Computational Bio- informatics Credits : 3

Introduction to DNA as information storage molecules for cells.

Data Searches and pair wise alignments: Dot plots, Gaps, Alignment. Dynamic Programming: Needleman and Wunch Algorithm. Global and Local Alignments.

Substitution Patterns: Estimating Substitution Numbers.

Phylogenetics: Distance–Based Methods: Phylogenetic trees, Distance Matrix Method. Character Based Methods: Parsimony, Searches, Tree confidence.

Computer Programming and Data structure: Programming fundamentals, Variables and Basic operations, Control and Looping. Structures, Data structure, Functions. Simple Program Creation in C and Execution.
Introduction to Genetic Algorithms: Introduction, Coding of Parameters, Reproduction, Cross Over, Mutation, Simple algorithm at work.

***References*:**

1. D.E. Krane, Michael L. Raymer, Fundamental Concept of Bio-informatics, Pearson Education Ltd. 2003.
2. T.K.Attwood, D.J.P.Smith, Intoduction to Bio-informatics, Pearson Education Ltd. 2003.
3. Bryan Bergaron, Bio-informatics computing, Pearson Education Ltd. 2003.

SEMESTER - IV

MTM 401 Functional Analysis Credits : 4

Bounded linear transformations. B(X,Y) as a normed linear space. Open mapping and closed graph theorems. Uniform boundedness principle and its consequences. Hahn-Banach theorem and its application. Dual spaces with examples. Separability. Reflexive spaces. Weak convergence. Compact operators.
Inner product spaces, Hilbert spaces. Orthonormal sets. Bessel's inequality. Complete orthonormal sets and Parseval's identity. Structure of Hilbert spaces. Projection theorem. Riesz representation theorem. Riesz-Fischer theorem. Adjoint of an operator on a Hilbert space. Reflexivity of Hilbert spaces. Self-adjoint operators. Positive, projection, normal, and unitary operators.

References:

1. G. F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, 1963.
2. G. Bachman and L. Narici, *Functional Analysis*, Academic Press, 1966.
3. A. E. Taylor, *Introduction to Functional Analysis*, John Wiley, 1958.
4. B. V. Limaye, *Functional Analysis*, Wiley Eastern.
5. N. Dunford and J. T. Schwartz, *Linear Operators*, Part-I, Interscience, 1958.
6. R. E. Edwards, *Functional Analysis*, Holt Rinehart and Winston, 1965.
7. C. Goffman and G. Pedrick, *First Course in Functional Analysis*, Prentice- Hall of India, 1987.
8. K. K. Jha, *Functional Analysis and Its Applications*, Students' Friend, 1986

MTM 402 Partial Differential Equations Credits : 4

Classisification, Characteristic equation. Some important linear PDE. Fundamental solution of Laplace's Equation. Mean value formulae, Harmonic functions and properties, Representation formula. Green's function, Green representation formula. Poisson representation formula, Solution of Dirichlet problem on the ball. Sub Hormonic functions. The maximum principle. Energy methods.
Fundamental solutions of Heat Equation, Mean value formulae, properties of solutions, Initial BVP for heat equation.
Wave Equation. Mean value Method, Solution of Wave equation with initial values, Energy methods.

References:

1. L. C. Evans, *Partial Differential Equations*, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.
2. Jurgen Jost, Partial Differential Equations: Graduate Text in Mathematics, Springer Verlag Heidelberg, 1998.
3. Robert C Mcowen, Partial Differential Equations: Methods and Applications, Pearson Education Inc. 2003.
4. Fritz John, *Partial Differential Equations*, Springer-Verlag, 1986.
5. I.N. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, 1988.

MAJOR ELECTIVE

(Any two of the following courses, each having 4 credits)

MTM 403 Fluid Mechanics Credits : 4

Laminar flow of viscous incompressible fluids-Similarity of flows. Buckingham Π-theorem. Flow between parallel flat plates: Couette and plane Poiseuille flows. Flow through a pipe: Hagen Poiseuille flow, flow between two co-axially cylinders and two concentric rotating cylinders. Unsteady motion of a flat plate. Lubrication.
Laminar boundary layer – Properties of Navier-Stokes equations. Boundary layer equations in two-dimensional flows. Boundary layer along a flat plate. Blausius solution. Boundary layer displacement and momentum-thicknesses. Momentum integral theorems with applications. Effect of pressure gradient on the boundary layer development. Separation of boundary layer flow.

Compressible Inviscid flow – Controlling parameters. Equations of continuity, motion, energy and pressure. Kelvin theorem. Propagations of motion. Formation of shock waves. Mach number, Mach lines and cones. Isentropic flow relations. Pressure density and temperature in terms of Mach number.

References:

1. F. Charlton, *A Text Book of Fluid Dynamics*, CBC, 1985.
2. S. W. Yuan, *Foundations of Fluid Mechanics*, Prentice-Hall, 1976.
3. S. I. Pai, *Introduction to the Theory of Compressible Flow*, Affiliated East-West Press, 1970.

MTM 404 Numerical Solutions of Partial Differential Equations Credits : 4

Numerical solutions of parabolic PDE in one space: two and three levels explicit and implicit difference schemes. Convergence and stability analysis.

Numerical solution of parabolic PDE of second order in two space dimension: implicit methods, alternating direction implicit (ADI) methods. Non linear initial BVP.

Difference schemes for parabolic PDE in spherical and cylindrical coordinate systems in one dimension.

Numerical solution of hyperbolic PDE in one and two space dimension: explicit and implicit schemes. ADI methods. Difference schemes for first order equations.

Numerical solutions of elliptic equations, approximations of Laplace and biharmonic operators. Solutions of Dirichlet, Neuman and mixed type problems.

Finite element method: Linear, triangular elements and rectangular elements.

References:

1. M. K. Jain, S. R. K. Iyenger and R. K. Jain, *Computational Methods for Partial Differential Equations*, Wiley Eastern, 1994.
2. M. K. Jain, *Numerical Solution of Differential Equations*, 2nd edition, Wiley Eastern.
3. S. S. Sastry, *Introductory Methods of Numerical Analysis*, , Prentice-Hall of India, 2002.
4. D. V. Griffiths and I. M. Smith, *Numerical Methods of Engineers*, Oxford University Press, 1993.
5. C. F. General and P. O. Wheatley *Applied Numerical Analysis*, Addison- Wesley, 1998.

MTM 405 Structures on Differentiable Manifolds-II Credits : 4

(Pre-requisite : MTM 307 Structures on Differentiable Manifolds-I)

Almost contact manifolds: Definitions, Certain properties, Lie-derivative, Normal contact structure, Affinely almost co-symplectic manifold, Almost contact 3-structure, Para contact structure.

Almost Grayan manifolds: Definitions, certain properties, D-conformal transformation, Particular affine connections, Almost contact Riemannian 3-structure, Subamnifolds.

Sasakian Manifolds: Definition, properties of a Quasi-Sasakian manifolds, Co-symplectic structure, some new definitions, 3-structure metric manifolds, sub-manifolds.

F-structure manifolds: Definitions, some properties, Integrability conditions, Almost quaternion and null-operations, Almost F-3-structure, Framed manifold.

Other Structures: Almost tangent structure and $\prod$-structure, Almost product and almost decomposable manifolds, A generalized structure and some of its properties.

Prequisite: Structures on Differentiable manifolds-I

References:

1. R.S. Mishra, *Structure on a Differentiable Manifold and their Applications*, Chandrama Prakashan, Allahabad, 1984.
2. K. Yano, *Differential Geometry of Complex and Almost Complex Spaces*, Pergamon Press, 1985.

MTM 406 Algorithms and Data Structures Credits : 4

Fundamentals of C Programming, Structures, Pointers. Introduction to the concepts of an abstract data structure and its implementation.

Mathematical Basis: Asymptotic notations, Summations, Recursion formulas.

Basic Data Structures: Stacks, queues, lists, trees, priority queues, tables.

Searching Methods: Binary search Tree.

Sorting: General Background, Insertion sorts, Merge sorts and Heap sort.

References:

1. Y.Langsam, M.J. Augenstein,A.M. Tanenbaum, Data Structures using C and C++ , PHI, New Delhi, 2002.
2. T.H. Cormen, C.E. Leiserson, R.C. Rivest, Algorithms, PHI New Delhi, 2001.
3. B.W. Kernighan and D.M. Ritchie, The C Porgramming Language 2nd Edition, (ANSI features) Prentice Hall, 1989.

MTM 407 Wavelets Credits : 4

Fourier Analysis: Fourier and inverse Fourier transforms, Convolution and delta function, Fourier transform of Square integrable functions. Fourier series, Basic Convergence Theory and Poisson's Summation formula.

Wavelet Transforms and Time Frequency Analysis: The Gabor Transform. Short-time Fourier transforms and the uncertainity principle. The integral wavelet transforms Dyadic wavelets and inversions. Frames. Wavelet Series.

Scaling Functions and Wavelets: Multi resolution analysis, scaling functions with finite two scale relations. Direct sum decomposition of $L^2(R)$. Linear phase filtering, Compactly supported wavelets, Wavelets and their duals, Orthogonal Wavelets and Wavelet packets, Example of orthogonal Wavelets. Identification of orthogonal two-scale symbols, Construction of Compactly supported orthogonal wavelets, Orthogonal wavelet packets, orthogonal decomposition of wavelet series.

References:

1. C.K.Chui, A First Course in Wavelets, Academic press NY 1996.
2. I. Daubechies, Ten Lectures in Wavelets, Society for Industrial and Applied Maths, 1992.

MTM 408 Cosmology Credits : 4

(Pre-requisite : MTM 306 Gravitation)

An overview of the large scale structure of the universe. Einstein's modified field equations with the cosmological term.

Static cosmological models of the Einstein and de-Sitler; their derivation, geometrical and physical properties and comparison with the actual universe.

Hubble's law, non-static cosmological models, cosmological principles and Weyl's postulate.

Derivation of the Robertson-Walker metric and its geometrical properties. Hubble and deceleration parameters. Red shift in the Robertson-Walker geometry.

Einstein's equations for the Robertson-Walker metric, fundamental dynamical equations of the standard big-bang cosmology-Friedman Robertson-Walker models. Initial singularity-the bang, density and pressure in the present universe. Critical density- the open, closed and flat universes. Age of the universe. The radiation and matter dominated era of the universe. The red shift versus distance relation. Event and particle horizons.

Prequisite: Gravitation.

References:

1. R. C. Tolman, *Relativity, Thermodynamics and Cosmology,* Clarendon Press, Oxford, 1934.
2. S. Weinberg, *Gravitation and Cosmology*, John Wiley, 1972.
3. J. V. Narlikar, *Introduction to Cosmology*, Cambridge University Press, 1998.
4. J. N. Islam, *An Introduction to Mathematical Cosmology*, Cambridge University Press, 1999.
5. J. A. Peacock, *Cosmological Physics*, Cambridge University Press, 1999

MTM 409 Category Theory Credits : 4

Categories, Functors and natural transformations. Monics, Epis and zeors. Construction on Categories, Duality. Contravariance and opposites. Products of categories, Functor Categories, Comma Categories, Universals and Limits. Universal arrows. The Yoneda lemma. Coproducts and Colimits. Products and Limits. Adjoints. Examples of Adjoints. Reflective Subcatgories. Equivalence of categories. Adjoints for preorders, cartesion closed categories. Limits, Creation of Limits, Limits by Products and Equailizer. Freyd's Adjoint Functor Theorem. Special Adjoint Functor Theorem. Adjoints in Topology. Monads and Algebras. Monads in a Category, Algebra for a Monad. The comparison with algebras. Words and free semi groups, Free Algebras for Monads. Beck's Theorem. Algebras are T-algebras. Compact Hausdorff Spaces.

References:

1 S. MacLane, Categories for the Working Mathematician, Springer 1971.

2 M.A. Arbib and E. G. Manes, Arrows, Structures and Functors- The Categorical Imperative, Academic Press, 1975.

3 H. Herrlich and G.E. Strecker, Category Theory, Allyn & Bacon, 1973.

4 J. Adamek, H. Herrlich & G. E. Streeker, Abstract and Concrete Categories, John Wiley 1992.

MINOR ELECTIVE

(Any one of the following courses, each having 3 credits: MTM 410- MTM 416)

MTM 410 Fuzzy Sets and Applications Credits: 3

Basic Concepts of Fuzzy Sets and Fuzzy Logic:Motivation. Fuzzy sets and their representations. Membership functions and their designing. Types of Fuzzy sets.Operations on fuzzy sets. Convex fuzzy sets. Alpha-level cuts. Geometric interpretation of fuzzy sets. Linguistic variables. Possibility measure and distribution. Fuzzy

rules. Fuzzy Relations and Fuzzy Arithmetic:Composition of fuzzy relations. Fuzzy numbers. Arithmetic operations on fuzzy numbers.
Fuzzy reasoning
Fuzzy mapping rules and fuzzy implication rules. Fuzzy rule-based models for function approximation. Types of fuzzy rule-based models (the Mamdani, TSK, and standard additive models). Fuzzy Implications and Approximate Reasoning:
Fuzzy Logic and Probability Theory :Possibility versus probability. Probability of a fuzzy event. Baye's theorem for fuzzy events. Probabilistic interpretation of fuzzy sets. Fuzzy measure.
Decision making in Fuzzy environment: Fuzzy Decisions, Fuzzy Linear programming, Fuzzy Multi criteria analysis, Multiobjective decision making.
Fuzzy databases and queries: Introduction, Fuzzy relational databases, Fuzzy queries in crisp databases.
References:

1. J. Yen and R. Langari: *Fuzzy Logic: Intelligence, Control, and Information,* Pearson Education*, 2003.*
2. G. J. Klir and B. Yuan: *Fuzzy Sets and Fuzzy Logic: Theory and Applications,* Prentice-Hall of India, *1997.*
3. H.J. Zimmermann, *Fuzzy Set theory and its Applications*, Kluwer Academic Publ, 2001.

MTM 411 Financial Mathematics Credits : 3

Some Basic Definitions and Terminology. Basic option theory: single and multi-period binomial pricing models. Cox-Ross-Rubinstein (CCR) model, Black Scholes formula for potion pricing as a limit of CCR model. Brownian ad Geometric Brownian Motion. Theory of Martingales. Stochastic Calculus, Stochastic differential Equations, Ito's formula to solve SDE's. Feymann Kac theorem. Application of stochastic calculus in option pricing. Black Scholes partial differential equations and Black Scholes formula.
Mean Variance portfolio theory: Markowitz model for Portfolio optimization and Capital Asset Pricing Model (CAPM).
Interest rates and interest rate derivatives: Binomial lattice model, Vasicek, Hull and White and Cox-Ingersoll-Ross (CIR) Model for bond pricing.
References:

1 D.G. Luembergar, Investment Science, Oxford University press, 1999.
2 S.Ross, An Introduction to Mathematical Finance, Cambridge University press, 1999.
3 J.C.Parikh, Stochastic Process and Financial Markets, Narosa, 2003.
4 S. Roman, An Introduction the Mathematics of Finance, Springer, 2000.

MTM 412 Number Theory and Cryptography Credits: 3

Number Theory: Introduction, Time estimates for doing arithmetic. Divisibilty and Euclidean algorithm. Congruencies. Some applications to factoring. Finite Fields and quadratic residues: Finite Fields, Quadratic Residues and Reciprocity.
Cryptography: Some simple crypto Systems. Enciphering matrices. Public Key: The Idea of Public key Cryptography. RSA. Discrete log. Knapsack. Zero-knowledge protocols and Oblivious Transfer. Pseudo Primes, Rho Method, fermat factorization and Factor bases.
References:

1. Neal Koblitz, A Course in Number Theory and cryptography: A Graduate Text, Springer (Second Ed).

MTM 413 Operator Theory Credits: 3

Spectral Theory of Linear Operators in Normed Spaces, Spectral Theory in Finite Dimensional Normed Spaces, Basic Concepts, Spectral properties of Bounded Linear Operators, Further Properties of Resolvant and Spectrum, Use of Complex Analysis in Spectral Theory. Banach Algebras, Further properties of Banach Algebra. Gelfard- Naimark theorem.

References:

1 E. Kreysyig, Introductory Functional Analysis with Applications, John Wiley and Sons.
2 John B. Coway, A Course in Operator Theory: A Graduate Studies in Mathematics, Springer.
3 G.Bachman, L. Narici, Functional analysis, Academic Press, N.Y.
4 G. F. Simmons, An Introduction to Topology and Modern Analysis, Tata McGrawHill.

MTM 414 Bio Mechanics Credits: 3

External Flow: Fluid Dynamic forces acting on moving bodies. Flying and swimming. Blood flow in Heart, Lung, arteries and veins. Micro and Macro Circulation. Respiratory gas flow. The Laws of Thermo dynamics. Molecular diffusion. Mechanism in Membrances and Multiphasic structure.
Mass transport in Capillaries, Tissues, Interistitial spaces. Lymphatics, Indicator dilution method and Peristlsis.

References:

1 Y.C.Fung, Bio Mechanics, Springer Verlag, NY 1990**.**
2 S.I. Rubinow, Introduction to Mathematical Biology, John Wiley, 1975.
3 Riccilardi, Biomathematics and Related Computational Problems, Kluwer Publ. 1988.
4 J. Keener, J. Sneyol, Mathematical Physiology, Springer, 2001
5 J.N.Kapoor, Mathematical Models in Biology and Medicine, EWP New Delhi, 1992.

MTM 415 Module Theory Credits: 3

Modules. Linear mapping. Transpose of a module, Homomorphism. Bimodules, Bilinear maps. Tensor product of modules. Exact and split-exact sequences. Small and essential submodules and their properties. Free modules, Projective modules, projective covers. Injective modules and injective envelopes.

References:

1 F.W.Anderson and K. R. Fuller, Rings and Categories of Modules. Springer, Verlag.
2 J. Lambek, Lectures on Rings and Modules, Blaisdell Publ. Co.
3 J.S. Golan, Modules and Structures of Rings, Marcel Dekkar Inc.

MTM 416 Advanced Graph Theory Credits: 3

Trees: Spanning trees and enumeration. Matching: Matching and Maximum Matching, Hall's Matching condition, Minimax Theorems. Independent Sets and Covers. Dominating Sets.

Connectivity: Connectivities of graphs, Cut-sets, Edge Connectivity and Vertex Connectivity. Menger's Theorem.

Network Flow problem, maximum network flows, flow augmenting paths, Ford-Fulkerson Theorem.

Coloring of graphs: Chromatic number and chromatic polynomial of graphs, Brook's Theorem. Four Color Theorem.

Planarity: Planar Graphs, Testing of Planarity, Kuratowski Theorem for Planar graphs, Random Graphs.

References:

1 D.B.West, Graph Theory , Pearson Publ. 2002.
2 F.Harary, Graph Theory. Narosa Publ. ND.
3 R. Diestel, Graph Theory, Springer, 2000.
4

MTM 417 Project Credits: 6

Some innovation in form of the written project, in Mathematics/application of Mathematics, based on the knowledge gained during the course of studies in view of the developments in Mathematics.

M. Sc. MOLECULAR & HUMAN GENETICS
Department of Molecular & Human Genetics
Banaras Hindu University

Semesterwise distribution of Courses and Credits

Semester-I		
Course Code	**Title**	**Credits**
MGM101	Transmission Genetics & Model Genetic Systems	4
MGM102	Basic Human Genetics	3
MGM103	Molecular Genetics	3
MGM104	Biochemistry & Biochemical Techniques	3
MGM105	Lab work based on courses MGM101 & MGM102	3
MGM106	Lab work based on courses MGM103 & MGM104	3
MGM107M # MGM108M # MGM109M # MGM110M # MGM111M # MGM112M # MGM113M # MGM114M # MGM115M # MGM116M # MGM117M # MGM118M # MGM119M # MGM120M # MGM121M # MGM122M # MGM123M # MGM124M # MGM125M # MGM126M # MGM127M # MGM128M # MGM129M # MGM130M # MGM131M # MGM132M # MGM133M # MGM134M # MGM135M # MGM136M # MGM137M # MGM138M # MGM139M # MGM140M # MGM141M # MGM142M # MGM143M # MGM144M # MGM145M # MGM146M # MGM147M # MGM148M # MGM149M # MGM150M # MGM151M # MGM152M # MGM153M # MGM154M # MGM155M # MGM156M # MGM157M # MGM158M # MGM159M # MGM160M # MGM161M # MGM162M # MGM163M # MGM164M # MGM165M # MGM166M # MGM167M # MGM168M # MGM169M # MGM170M # MGM171M # MGM172M # MGM173M # MGM174M # MGM175M # MGM176M # MGM177M # MGM178M # MGM179M # MGM180M # MGM181M # MGM182M # MGM183M # MGM184M # MGM185M # MGM186M # MGM187M # MGM188M # MGM189M # MGM190M # MGM191M # MGM192M # MGM193M # MGM194M # MGM195M # MGM196M # MGM197M # MGM198M # MGM199M # MGM200M # MGM201M # MGM202M # MGM203M # MGM204M # MGM205M # MGM206M # 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SEMESTER - I

MGM101: Transmission Genetics & Model Genetic Systems **Credits: 4**

Section A: Transmission Genetics **Lecture hours**

1 Introduction to Genetics 1

2 Mendelism 9

2.1 Mendel and his experiments
2.2 Law of segregation
2.3 Law of independent assortment
2.4 Application of laws of probability (product rule, sum rule)
2.5 Chromosomal basis of segregation and independent assortment

3 Chi-square test and its application in analysis of genetic data 1

4 Extensions of Mendelism 9

4.1 Allelic variation and gene function- Dominance relationships, basis of dominant and recessive mutations
4.2 Multiple allelism, allelic series
4.3 Testing gene mutations for allelism: complementation test, intragenic complementation
4.4 Visible, sterile and lethal mutations
4.5 Genotype to phenotype: effect of the environment on phenotype development- Penetrance and expressivity, phenocopy
4.6 Gene interactions and modifying genes
4.7 Pleiotropy

5 Sex-linked inheritance, Linkage and crossing over 10

5.1 Genetic recombination and construction of genetic maps in Drosophila
5.2 Interference and coincidence
5.3 Cytological demonstration of crossing over in Drosophila
5.4 Mitotic recombination
5.5 Intragenic recombination

6 Inheritance of quantitative traits 6

6.1 Continuous and discontinuous variation
6.2 Polygenic inheritance
6.3 Genetic variance, heritability (narrow sense and broad sense)

7 Cytoplasmic inheritance, maternal effects, inheritance due to parasites and symbionts 3

Recommended Books:

1 Atherly et al (1999). The Science of Genetics. Saunders
2 Brooker (1999). Genetics – Analysis and Principles. Benjamin/Cumings
3 Fairbanks et al (1999). Genetics. Wadsworth
4 Gardner et al (1991). Principles of Genetics. John Wiley
5 Griffiths et al (2002). Modern genetic Analysis. Freeman
6 Griffiths et al (2004). An Introduction to Genetic Analysis. Freeman
7 Hartl and Jones (1998). Genetics – Principles and Analysis. Jones & Bartlett
8 Snustad et al (1998). Principles of Genetics. Wiley and sons
9 Strickberger (1985). Genetics. Mcmillan
10 Tamarin (1996). Principles of Genetics. WCB

Section B: Model Genetic System

1 Life cycles and advantages of the following organisms commonly used in genetic studies 8

1.1 T4 and l phages
1.2 Neurospora
1.3 E.coli
1.4 Saccharomyces cerevisea and Schizosaccharomyces pombe
1.5 Caenorhabditis
1.6 Drosophila

1.7 Zebra fish
1.8 Mouse

2 Conventions of nomenclature of genes and gene products in different model systems 5

Recommended Books

1 Ashburner (1989). Drosophila - A Laboratory Handbook. CSHL Press
2 Demerec & Kaufmann(1965). Drosophila Guide. Carnegie
3 Hood(1998). The Nematode: C. elegans. CSHL
4 Trends in Genetics(1998). Genetic Nomenclature Guide. Elsevier

MGM102: Basic Human Genetics **Credits: 3**

1 History of Human Genetics 1

2 Pedigrees- gathering family history, pedigree symbols, construction of pedigrees, presentation of molecular genetic data in pedigrees 1

3 Monogenic traits 12

3.1 Autosomal inheritance-dominant, recessive
3.2 Sex-linked inheritance
3.3 Sex-limited and sex-influenced traits
3.4 Mitochondrial inheritance
3.5 MIM number
3.6 Complications to the basic pedigree patterns- nonpenetrance, variable expressivity, pleiotropy, late onset, dominance problems, anticipation, genetic heterogeneity, genomic imprinting and uniparental disomy, spontaneous mutations, mosaicism and chimerism, male lethality, X-inactivation
3.7 Risk assessment; application of Bayes' theorem
3.8 Allele frequency in population
3.9 Consanguinity and its effects

4 Complex traits 10

4.1 Approaches to analysis of complex traits- 'Nature -nurture' concept, role of Family and shared environment, monozygotic and dizygotic twins and adoption studies
4.2 Polygenic inheritance of continuous (quantitative) traits, normal growth charts, Dysmorphology
4.3 Polygenic inheritance of discontinuous (dichotomous) traits- threshold model, liability and recurrence risk
4.4 Genetic susceptibility in multifactorial disorders (alcoholism, diabetes mellitus, obesity)
4.5 Estimation of genetic components of multifactorial traits: empiric risk, heritability, coefficient of relationship

5 Human cytogenetics 10

5.1 Techniques in human chromosome analysis
5.2 Human karyotype: banding, nomenclature of banding
5.3 Pathology of human chromosomes
5.4 Nomenclature of aberrant karyotypes

5.5 Common syndromes due to numerical chromosome changes
5.6 Common syndromes due to structural alterations (translocations, duplications, deletions, microdeletion, fragile sites)
5.7 Common chromosome abnormalities in cancer
5.8 Genetics of fetal wastage

6 Pharmacogenetics and ecogenetics 5

Recommended Books

1 Connor & Smith (1997). Essentials of Medical Genetics. Blackwell
2 Davies (1993). Human Genetic Disease Analysis. IRL
3 Emery and Mueller (1992). Elements of Medical Genetics. ELBS
4 Gersen & Keagle (2005). The Principles of Clinical Cytogenetics. Humana
5 Jorde et al (2005). Medical Genetics. Elsevier
6 Korf (2006). Human Genetics. Blackwell
7 Lewis (2006). Human Genetics. WCB
8 Mange and Mange (2005). Basic Human Genetics. Sinauer Assoc
9 Maroni (2001). Molecular and Genetic Analysis of Human Traits. Blackwell
10 Nussbaum et al (2004). Genetics in Medicine. Saunders
11 Pasternak (2005). An Introduction to Molecular Human Genetics. Fritzgarald
12 Prichard & Korf (2004). Medical Genetics at a glance. Blackwell
13 Strachan and Read (2003). Human Molecular Genetics. Wiley
14 Vogel and Motulsky (1997). Human Genetics. Springer

MGM103: Molecular Genetics **Credits: 3**

1 Properties and evolution of genetic material, flow of genetic information 2

2 Organization of viral and bacterial genomes 2

3 Eukaryotic genome 5

3.1 C-value paradox
3.2 Repetitive DNA
3.3 General concept of a gene
3.4 Gene families
3.5 Non-coding genes

4 Replication in bacterial and eukaryotic chromosomes 5

4.1 DNA polymerases
4.2 Replicons, origin and termination
4.3 Replisome
4.4 Genes controlling replication

5 Transcription 5

5.1 Prokaryotic RNA polymerase, sigma factors, initiation and termination
5.2 Eukaryotic RNA polymerases and their promoters
5.3 Processing of transcripts

6 Translation 2

6.1 General mechanism
6.2 Role of rRNA in translation

7 Regulation of gene expression 8

7.1. Regulation of transcription initiation

7.1.1. Operon and regulon
7.1.2. Positive and negative regulation
7.1.3. Enhancers and promoters

7.1.4. Transcription factors: types, DNA binding motifs

7.2. Regulation by attenuation and anti-termination

7.3. Post transcriptional regulation

7.3.1. Alternative splicing
7.3.2. Transport and targeting of RNA
7.3.3. Post-transcriptional gene silencing

7.4. Translational control and targeting of proteins
7.5. Mechanism of steroid hormone and stress induced gene expressions

8	Mutation: Types and detection	3
9	Gene mapping in bacteria	4

9.1. Transformation
9.2. Conjugation
9.3. Transduction
9.4. Sexduction

10	Recombination, deletion and complementation mapping in T4 phage (rII locus)	3

Recommended Books

1 Alberts et al (1999). The Science of Genetics. Saunders
2 Benjamin (2003). Genetics: A Conceptual Approach. Freeman
3 Berg and Singer (1998). Genes and Genome.
4 Black (2002). Microbiology: Principles and Explorations. Wiley
5 Dale & Schartz (2003). From genes to Genome. Wiley & Sons
6 Griffiths et al (2002). Modern Genetic Analysis. Freeman
7 Griffiths et al (2004). An Introduction to Genetic Analysis. Freeman
8 Hartl et al (2002). Essential Genetics. Wiley & Sons
9 Klug & Cummings (2003). Essentials of Genetics. Prentice Hall
10 Latchman (1995). Gene Regulation. Chapman & Hall
11 Lewin (2007). Genes IX. Pearson
12 Maloy and Freifelder (1994). Microbial Genetics. Jones and Barlett
13 Meesfeld (1999). Applied Molecular Genetics. Wiley-Liss
14 Ptashne (1986). Genetic Switch. Blackwell
15 Russell (2002). Genetics. Benjamin
16 Streips & Yasbin (2002). Modern Microbial Genetics. Wiley
17 Trun & Trempy (2004). Fundamentals of Bacterial Genetics. Blackwell
18 Watson et al. (2004). Molecular Biology of the Gene. Pearson

MGM104: Biochemistry & Biochemical Techniques **Credits: 3**

1	Nucleic Acids: 1.1 structure and conformations 1.2 Nucleic acid chemistry: non enzymatic transformation and methylation	5
2	Nucleotide Metabolism 2.1. Synthesis and degradation of pyrimidine and purine nucleotides 2.2. Disorders of nucleotide metabolism 2.3. Functional diversity of nucleotides	4
3	Amino acids and peptides 3.1. Essential and non-essential amino acids 3.2. Amino acids related disorders 3.3. Small peptides and their biomedical importance	6
4	Proteins 4.1. Structure-conformation-function relationship (exemplified by Myoglobin, Hemoglobin, and Collagen) 4.2. Protein degradation	5
5	Enzymes 5.1. General properties 5.2. Kinetics: derivation of Michaelis-Menten equation, L-B plot 5.3. Enzyme inhibition 5.4. Mechanism of action 5.5. Regulation of enzyme activity	9
6	Biochemical techniques 6.1. Centrifugation: types of rotors, clinical, highspeed and ultracentrifuges 6.2. Colorimetry and spectrophotometry: Beer-Lambert law; absorption spectrum, fluorescence spectrum, introduction to mass spectrometry 6.3. Chromatography: Paper, Thin layer chromatography; Columns: ion-exchange, gel-filteration, HPLC and affinity columns, electrophoresis 6.4. Tracer techniques: Properties and units of radioactivity; half-life; measurement of radioactivity by GM counter, liquid scintillation counter; autoradiography; radio-immunoassay; safety rules in handling of radioisotopes and hazardous chemicals	10

Recommended Books

1 Berg et al (2006). Biochemistry. Freeman
2 Bhagwan (2004). Medical Biochemistry. AP
3 Devlin (2002). Biochemistry for the Molecular Sciences. Wiley
4 Higgins et al (1994). Biochemistry for the Molecular Sciences Longman
5 Murray et al (2006). Harpers Illustrated Biochemistry. Prentice Hall
6 Nelson et at (2006). Lehninger's Principles of Biochemistry. McMillan
7 Voet & Voet (2006). Biochemistry Vol. 1 and 2. Wiley
8 Zubay et al (1995). Principles of Biochemistry. WCB
9 Boney (1982). Cell Biology Level II. Macdonald & Evans
10 Boyer (1993). Modern Experimental Biochemistry. Benjamin
11 Clark & Switzer (2000). Experimental Biochemistry. Freeman
12 Freifelder (1987). Physical Biochemistry. Freeman
13 Boyer 2007 (2007). Concept of Biochem. 3rd Ed

MGM105	Lab work based on courses MGM101 & MGM102	**Credits: 3**
MGM106	Lab work based on courses MGM103 & MGM104	**Credits: 3**

MGM107M: Reproductive Genetics & Genetics of Pathogens Credits: 3

Section A: Reproductive Genetics

1	Male and female reproductive systems	10
	1.1. Gonads and differentiation of sexual characters 1.2. Hormonal regulation of sexual differentiation	
2	Reproductive disorders	11
	2.1. Disorders of gonads, genital tracts and genitalia	
	2.1.1. Pseudohermaphroditism 2.1.2. True hermaphroditism 2.1.3. Gonadal dysgenesis 2.1.4. Anomalies of genital ducts	
	2.2. Infertility	
	2.2.1. Genetic basis of male infertility 2.2.2. Genetic basis of female infertility 2.2.3. Recurrent pregnancy loss	
3	Technologies in reproductive assistance	3
4	Legal and ethical implications in reproductive assistance	2

Recommended Books

1 Besser & Thorner (2002). Comprehensive clinical endocrinology. Mosby
2 Rimoin et al (2002). Principles & Practice of Medical Genetics, Vol I-III. Churchill

Section B: Genetics of Pathogens

1	Host-pathogen interaction, evolution of pathogenecity and regulation of virulence	2
2	Mechanism of drug resistance in pathogens	2
3	Molecular biology of following pathogens: HIV, Hepatitis viruses, Mycobacterium tuberculosis, Vibrio cholerae, Plasmodium, Leishmania, Trypanosoma, Entamoeba	8
4	Molecular mechanisms for origin of new pathogens	1

Recommended Books

1 Heritage et al (1996). Introductory Microbiology. Cambridge Univ.
2 Madigen et al(1997). Biology of Microorganisms. Prentice Hall
3 Nesler et al (1995). Microbiology-A Human Perspective. WCB
4 Pelczar et al(1993). Microbiology. Tata
5 Prescott et al (1999). Microbiology. WCB
6 Reischel (1998). Molecular Diagnosis of Infectious Diseases. Humana
8 Streips & Yasbin (2002). Modern Microbial Genetics. Wiley
9 Trun & Trumpy (2004). Fundamentals of Bacterial Genetics. Blackwell
10 Volk et al (1991). Essentials of Medical Microbiology. Lippincott & Co

SEMESTER - II

MGM201: Cell Biology & Microscopy **Credits: 3**

1	Plasma Membrane: organization and dynamics transport across membrane; mechanisms of endocytosis and exocytosis	4
2	Endomembrane system 2.1. General organization of protein transport within and outside the cell 2.2. Protein sorting and secretion 2.3. Mechanism of intracellular digestion	5
3	Cytoskeleton 3.1. Microfilaments: Structural organization, cell motility and cell shape 3.2. Microtubule: Structural and functional organization, cilia, flagella, centriole 3.3. Intermediate filaments	4
4	Mitochondria 4.1 Ultrastructure 4.2 Chemiosmotic theory and respiratory chain complexes	2
5	Structure and function of peroxisome	1
6	Nucleolus and biosynthesis of ribosome	2
7	Cell cycle and its regulation	3
8	Cell-Cell Interaction 8.1. Cell adhesion molecules 8.2. Cellular junctions 8.3. Extracellular matrix	5
9	Signal transduction 9.1. Intracellular receptor and cell surface receptors 9.2. Signalling via G-protein linked receptors (PKA, PKC, CaM kinase) 9.3. Enzyme linked receptor signaling pathways	5
9.4.	Network and cross-talk between different signal mechanisms	
10	Programmed cell death	1
11	Basic knowledge of principles and applications of the following microscopy techniques 11.1. Light Microscopy 11.2. Dark-field Microscopy 11.3. Phase-contrast Microscopy 11.4. Fluorescence Microscopy 11.5. Confocal Microscopy 11.6. Electron Microscopy 11.7. Photography, Digital imaging and image Processing	7

Recommended Books

1 Alberts et al (1998). Essential Cell Biology. Garland
2 Alberts et al (2007). Molecular Biology of the Cell. Garland
3 Cooper (2007). The Cell: A molecular Approach. ASM Press
4 Gilbert (2006). Developmental Biology. Sinauer
5 Jeremy et al (2002). Biochemistry. Freeman
6 Karp (2005). Cell and Molecular Biology. John Wiley
7 Lewin (2007). Genes IX. Pearson
8 Lodish et al (2004). Molecular Cell Biology. Freeman
9 Pollard &Earnshaw (2002). Cell Biology. Saunders
10 Tobin and Morcel (1997). Asking about Cells. Saunders
11 Wilson & Hunt (2002). The Cell: A Problems Approach. Garland
12 Locquin and Langeron (1983). Handbook of Microscopy. Butterwaths
13 Tobin and Morcel (1997). Asking about Cells. Saunders

MGM202: Cytogenetics **Credits: 3**

1	Chromatin structure	4
	1.1. Histones, DNA 1.2. Nucleosome and higher level organisation	
2	Chromosome organization	8
	2.1. Metaphase chromosome: centromere and kinetochore, telomere and its maintenance; Holocentric chromosomes and supernumerary chromosomes 2.2. Chromosomal domains (matrix, loop domains) and their functional significance 2.3. Heterochromatin and euchromatin, position effect variegation, boundary elements 2.4. Chromosome bandings	
3	Functional states of chromatin and alterations in chromatin organization	3
4	Structural and functional organization of interphase nucleus	2
5	Giant chromosomes	4
	5.1 Polytene chromosomes 5.2 Lampbrush chromosomes	
6	Mitosis	3
	6.1. Mitotic spindle and arrangement of chromosomes on equator 6.2. Regulation of exit from metaphase 6.3. Chromosome movement at anaphase	
7	Meiosis	5
	7.1 Overview of the process 7.2 Meiosis specific cellular changes 7.3 Genetic control of meiosis (example: yeast)	
8	Chromosomal anomalies	5
	8.1 Numerical 8.2 Structural 8.3 Meiosis in inversion and translocation heterozygotes; breakage-fusion-bridge cycles 8.4 Induced chromosomal aberrations in somatic cells 8.5 Sister chromatid exchanges and somatic crossing over	
9	Dosage compensation in Caenorhabditis, Drosophila and mammals	5

Recommended Books

1 Alberts et al (1998). Essential Cell Biology. Garland
2 Alberts et al (2007). Molecular Biology of The Cell. Garland
3 Bostoc and Sumner (1980). The Eukaryotic Chromosome. Elsevier
4 Hamsew and Flavell (1993). The Chromosome. Bios
5 Hawley & Walker (2003). Advanced Genetic Analysis. Blackwell
6 Hennig (1987). Structure & Function of Eukaryotic Chromosomes. Springer
7 Lewin (2007). Genes IX. Pearson
8 Lodish et al (2004). Molecular Cell Biology. Freeman
9 Obe and Natarajan(1990). Chromosome aberrations - Basic and Applied Aspects. Springer
10 Risley (1985). Chromosome Structure and Function. Reinhold
11 Rooney & Czepulkowski (1987). Human Cytogenetics – A Practical Approach. IRL
12 Sumner. Chromosomes. Blackwell

MGM203: DNA Technology & Genetic Engineering **Credits: 3**

1	Enzymes used in DNA technology 1.1 Restriction and modification enzymes 1.2 Other nucleases 1.3 Polymerases 1.4 Ligase, kinases and phosphatases	4
2	Cloning vectors 2.1 Plasmids 2.2 Phages 2.3 Cosmids 2.4 Artificial chromosomes 2.5 Shuttle vectors 2.6 Expression vectors	6
3	Construction of genomic and cDNA libraries	2
4	Screening and characterization of clones 4.1 Preparation of probes 4.2 Principles of hybridizations and hybridization based techniques (colony, plaque, Southern, Northern and in situ hybridizations) 4.3 Expression based screening 4.4 Interaction based screening: yeast two-hybrid system	5
5	Basic principles and applications of the following techniques 5.1. DNA sequencing 5.2. Oligonucleotide synthesis 5.3. Polymerase Chain Reaction 5.4. Microarray 5.5. DNA fingerprinting	5
6	Promoter characterization: promoter analysis through reporter genes, electrophoretic mobility shift assay, DNA foot-printing	3
7	Mutagenesis 7.1. Site directed mutagenesis 7.2. Transposon mutagenesis 7.3. Construction of knock-out mutants	3
8	Gene transfer techniques 8.1 Electroporation and microinjection 8.2 Transfection of cells: Principles and methods 8.3 Germ line transformation in *Drosophila* and transgenic mice: Strategies and methods	5
9	Applications of Recombinant DNA Technology 9.1 Crop and live-stock improvement 9.2 Gene therapy: somatic and germ line gene therapy 9.3 DNA drugs and vaccines 9.4 Bio safety and ethical considerations	6

Recommended Books

1 Ausubel et al (2002). Short Protocols in Molecular Biology. Wiley
2 Brown (2000). Essential Molecular Biology VI. AP
3 Brown (2000). Essential Molecular Biology VII. AP
4 Brown (2006). Gene Cloning and DNA Analysis - An Introduction. Blackwell
5 Glick and Pasternak (2003). Molecular Biotechnology. ASM Press
6 Kracher. Molecular Biology - A Practical Approach.
7 Krenzer and Massey (2000). Recombinant DNA and Biotechnology. ASM

8 Micklos and Freyer (1990). DNA Science. CSHL
9 Primrose (2001). Molecular Biotechnology. Panima
10 Robertson et al (1997). Manipulation & Expression of Recombinant DNA. AP
11 Sambrook et al (2001). Molecular Cloning. CSHL
12 Twyman (1999). Advanced Molecular Biology. Viva
13 Watson et al (1992). Recombinant DNA. Freeman
14 Primrose and Twyman (2006). Principles of Gene Manipulation and Genomics. Blackwell

MGM204: Genomic instability and Cancer & Bioinformatics Credits: 3

Section A: Genomic instability & Cancer

1	DNA repair 1.1. Origins and types of DNA damage 1.2. DNA repair pathways 1.3. Error-prone repair and mutagenesis 1.4. Damage signaling and checkpoint arrest	5
2	Recombination 2.1. Homologous recombination: models and molecular mechanisms 2.2. Gene conversion: molecular mechanisms 2.3. Site specific recombination 2.4. Transposons and transposition mechanisms	4
3	Cell transformation and tumourigenesis 3.1. Cell cycle check point and cancer 3.2 Oncogenes 3.3. Tumour suppressor genes 3.4. DNA repair genes and genetic instability 3.5. Epigenetic modifications, telomerase activity, centrosome malfunction 3.6. Genetic heterogeneity and clonal evolution	8
4	Familial cancers: Retinoblastoma, Wilms' tumour, Li-Fraumeni syndrome, colorectal, cancer, breast cancer	4
5	Genetic predisposition to sporadic cancer	1
6	Tumour progression: angiogenesis and metastasis	2
7	Tumour specific markers	1
8	Cancer and environment: physical, chemical and biological carcinogens	1

Recommended Books

1 Alberts et al (1999). The Science of Genetics. Saunders
2 Alberts et al (2008). Molecular Biology of the Cell. Garland
3 Benjamin (2003). Genetics: A Conceptual Approach. Freeman
4 Berg and Singer (1998). Genes and Genome.
5 Black (2002). Microbiology: Principles and Explorations. Wiley
6 Cowell (2001). Molecular Genetics of Cancer. Bios
7 Dale & Schartz (2003). From genes to Genome. Wiley & Sons
8 Ehrlich (2000). DNA Alterations in Cancer. Eaton
9 Gersen & Keagle (1999). Principles of Clinical Cytogenetics. Humana
10 Griffiths et al (2002). Modern Genetic Analysis. Freeman
11 Griffiths et al (2004). An Introduction to Genetic Analysis. Freeman
12 Hartl et al (2002). Essential Genetics. Wiley & Sons
13 Klug & Cummings (2003). Essentials of Genetics. Prentice Hall
14 Latchman (1995). Gene Regulation. Chapman & Hall
15 Lewin (2004). Genes VIII. Pearson
16 Lewin (2007). GenesIX. Pearson
17 Lodish et al (2004). Molecular Cell Biology. Freeman
18 Maloy and Freifelder(1994). Microbial Genetics. Jones and Barlett

19 Meesfeld (1999). Applied Molecular Genetics. Wiley-Liss
20 Ptashne (1986). Genetic Switch. Blackwell
21 Russell (2002). Genetics. Benjamin
22 Stillman (1994). Molecular Genetics of Cancer. CSHL
23 Streips & Yasbin (2002). Modern Microbial Genetics. Wiley
24 Trun & Trempy (2004). Fundamentals of Bacterial Genetics. Blackwell

Section B: Bioinformatics

1. Definition and Scope of Computational Biology and Bioinformatics 1
2. Major Bioinformatics Databases & Resources: NCBI, EBI, ExPASy 1
3. Biological **Sequence Analysis** 5

3.1 **Sequence Similarity, Homology and Alignment:**

3.1.1. Pairwise sequence Alignment, Global & Local Alignment algorithms, Basic concept of Scoring matrices (PAM & BLOSSUM), Dynamic programming Algorithms, Dot Plots for comparing sequences, Statistical significance of alignments score, motifs and pattern analysis

3.1.2. BLAST and FASTA algorithms BLAST theory, other BLAST options, PSI-BLAST and PSSM, Applications of BLAST.

3.2 **Multiple sequence alignment:** 2

3.2.1 Introduction to Multiple sequence alignment and progressive alignment algorithm, MSA based software tools ClustalW. Applications of Multiple Sequence alignment.

3.2.2 **Phylogenetic analysis:** 2

Definition and description of phylogenetic trees and various types of trees, A primer on Computational phylogenetic analysis.

4. Computational Gene Prediction Methods (basic concept) 2
5. Lab Exercises 26

5.1 Basics of Computer, Internet and Operating system

5.2 Major Sequence and Structure Databases**:** Knowledge of the following databases with respect to: organization of data, contents and formats of database entries, retrieval of data using text-based search tools

5.2.1 Nucleic acid sequence databases: GenBank, EMBL
5.2.2 Protein sequence databases: SWISS-PROT, TrEMBL, PIR
5.2.3. Genome Databases at NCBI, EBI, TIGR, SANGER
5.2.4. Repositories for high throughput genomic sequences: EST, STS and GSS
5.2.5. **Derived Databases**: basic concept of derived databases, PROSITE, PRODOM, Pfam, CATH, SCOP, DSSP, FSSP, DALI databases

5.3 Protein Structure Visualization**: Schematic Representations of proteins using** Chimera, and Pymol, Protein Data Bank (PDB) and PDB format.

Recommended Books

1 Attwood & Parry-Smith (2002). Introduction to Bioinformatics. Pearson
2 Barnes & Gray (ed) (2003). Bioinformatics for Geneticists. Wiley
3 Lesk (2003). Introduction to Bioinformatics. Oxford
4 Mount (2003). Bioinformatics: Sequence and Genome Analysis. CBS
5 Rashidi & Buchler (2000). Bioinformatics Basics. CRC Press
6 Rastogi et al (2003). Bioinformatics: Concepts, Skills and Applications. CBS
7 Westhead et al (2003). Bioinformatics Instant Notes. Viva Books

MGM205: Biochemistry & Metabolic Disorders **Credits: 3**

1 Carbohydrates 9
- 1.1. Mucopolysaccharides and related disorders
- 1.2. Glycolysis
- 1.3. Krebs cycle
- 1.4. Gluconeogenesis
- 1.5. Glycogenesis and glycogenolysis,
- 1.6. Disorders of glycogen metabolism

2 Lipids 8
- 2.1. Fatty acids: synthesis and oxidation of fatty acids
- 2.2. Ketogenesis
- 2.3. Metabolism of cholesterol
- 2.4. Lipoproteins: role in lipid transport and storage
- 2.5. Prostaglandins: structure and function

3 Bioenergetics 5
- 3.1. Second law of thermodynamics
- 3.2. High energy compounds
- 3.3. Oxidative phosphorylation

4 Hormones 8
- 4.1 Characteristics
- 4.2. Mechanism of action of peptide hormones
- 4.3 Mechanism of action of steroid hormones and gene expression
- 4.4 Hormonal regulation of fuel metabolism
- 4.5. Hormone receptors and diseases

5 Vitamins 4
- 5.1 Structure
- 5.2 Function of water- and lipid-soluble vitamins

6 Inborn errors of metabolism 5
- 6.1 Phenylketonuria
- 6.2 Maple syrup urine syndrome
- 6.3 Mucopolysaccharidosis
- 6.4 Galactesemia
- 6.5 Tay-Sachs disease

Recommended Books

1 Berg et al (2006). Biochemistry. Freeman
2 Bhagwan (2004). Medical Biochemistry. AP
3 Devlin (2002). Biochemistry: with clinical correlations. Wiley
4 Higgins et al (1994). Biochemistry for the Molecular Sciences. Longman
5 Murray et al (2006). Harpers Illustrated Biochemistry. Prentice Hall Int
6 Nelson et al (2006). Lehninger's Principles of Biochemistry. McMillan
7 Voet & Voet (2006). Biochemistry Vol. 1 and 2. Wiley
8 Zubay et al (1995). Principles of Biochemistry. WCB

MGM206	Lab work based on courses MGM201 & MGM202	**Credits: 2**
MGM207	Lab work based on courses MGM203 & MGM204	**Credits: 2**
MGM208	Lab work based on course MGM205	**Credits: 2**

MGM209M: Fundamentals of Molecular Biology **Credits: 3**

1	Eukaryotic cell Organization	4
	1.1 Biomembrane 1.2 Organelles of Eukaryotic cell	
2	Nucleic Acids	6
	2.1 Base composition, structure and conformation 2.2 Different forms and unusual structures 2.3 Nucleic acid chemistry: Denaturation, hybrids, nonenzymatic transformation, methylation. 2.4 Nucleosome &higher level Organization	
3	DNA Replication	5
	3.1 DNA polymerases 3.2 Replicons, origin and termination 3.3 Replisome 3.4 Genes controlling replication	
4	Transcription	8
	4.1 Prokaryotic RNA polymerase, sigma factors, initiation and termination 4.2 Eukaryotic RNA polymerases and their promoters 4.3 Processing of transcripts 4.4 Post transcriptional regulation: 4.4.1 Alternative splicing 4.4.2 Transport and targeting of RNA 4.4.3 Post-transcriptional gene silencing5	
5	Translation	3
	5.1 General mechanism 5.2 Translational control	
6	DNA Technology	13
	6.1 Enzyme used in DNA technology 6.2 Purification & separation of nucleic acid 6.3 Cloning 6.4 Polymerase chain reaction & application 6.5 DNA sequencing 6.6 DNA fingerprinting 6.7 Nucleic acid &protein hybridization techniques: southern, northern, western hybridization	

Recommended Books

1 Lodish et al (2004). Molecular Cell Biology. Freeman
2 Gerald Karp (2005). Cell & Molecular Bology. Wiley & Sons
3 Brown (2001). Essential Molecular Biology. AP
4 Alberts et al (1999). The Science of Genetics. Saunders
5 Benjamin (2003). Genetics: A Conceptual Approach. Freeman
6 Berg and Singer (1998). Genes and Genome
7 Dale & Schartz (2003). From genes to Genome. Wiley & Sons
8 Griffiths et al (2002). Modern Genetic Analysis. Freeman
9 Griffiths et al (2004). An Introduction to Genetic Analysis. Freeman
10 Hartl et al (2002). Essential Genetics. Wiley & Sons
11 Klug & Cummings(2003). Essentials of Genetics. Prentice Hall
12 Latchman (1995). Gene Regulation. Chapman & Hall
13 Lewin (2007). GenesIX. Pearson
14 Watson et al (2004). Molecular Biology of the Gene. Pearson

SEMESTER - III

MGM301: Human Molecular Genetics **Credits: 3**

1 Genetic mapping of Mendelian traits 6

1.1. Identifying recombinants and nonrecombinants in pedigrees
1.2. Genetic and physical map distances
1.3. Genetic markers
1.4. Two-point mapping- LOD score analysis
1.5. Multipoint mapping
1.6. Homozygosity mapping

2 Genetic mapping of complex traits 6

2.1. Difficulties in mapping complex traits
2.2. Allele sharing methods- Affected sib pair analysis
2.3. Allelic association, Linkage disequilibrium mapping, Transmission disequilibrium test

3 Physical mapping methods 6

3.1. Low resolution mapping- Cell hybrids, mini- and microcells, synteny of genes, Radiation hybrid mapping
3.2. Assembly of clone contigs
3.3. Identifying genes in cloned DNA
3.4. Integration of cytogenetic, genetic and physical maps

4 Identifying human disease genes 6

4.1. Principles and strategies
4.2. Position-independent and positional cloning. Candidate gene approaches
4.3. Confirming a candidate gene- mutation screening, testing in animal models

5 Molecular pathology 7

5.1. Nomenclature of mutations and their databases
5.2. Loss-of-function and gain-of-function mutations in diseases
5.3. Instability of the human genome: Pathogenicity associated with repeat sequences

6 DNA testing 8

6.1. Direct testing

6.1.1. Screening for unknown mutations
6.1.2. Detection of known mutations

6.2. Indirect testing – gene tracking
6.3. DNA profiling: establishing identity and relationships
6.4. Population screening - ethics, organization and advantages

Recommended Books

1 Davies (1993). Human Genetic Disease Analysis. IRL
2 Haines & Pericak (2006). Approaches to Gene Mapping in Complex Human Diseases. Wiley
3 Nussbaum et al (2004). Genetics in Medicine. Saunders
4 Pasternak (2005). An Introduction to Molecular Human Genetics. Fritzgerald
5 Rimoin et al (2002). Principles & Practice of Medical Genetics, Vol I-III. Churchill
6 Strachan & Read (1999). Human Molecular Genetics. Wiley
7 Sudbery (2002). Human Molecular Genetics. Prentice-Hall

MGM302: Clinical Genetics & Genetic Counseling **Credits: 3**

1	An overview of the genetic basis of syndromes and disorders	1
2	Monogenic diseases with well known molecular pathology 2.1. Cystic fibrosis 2.2. Tay-Sachs syndrome 2.3. Marfan syndrome 2.4 Inborn errors of metabolism	6
3	Genome imprinting Syndromes: Prader-Willi & Angelman syndromes, Beckwith-Wiedeman Syndrome	2
4	Neurofibromatosis I	1
5	Disorders of muscle 5.1 Dystrophies (Duchenne Muscular dytstrophy and Becker Muscular Dystrophy) 5.2 Myotonias 5.3 Myopathies	3
6	Disorders of Haemopoitic systems 6.1 Overview of Blood cell types and haemoglobin 6.2 Sickle cell anemia 6.3 Thalassemias 6.4 Hemophilias	4
7	Disorders of eye 7.1 Retinitis pigmentosa 7.2 Cataract 7.3 Glaucoma 7.4 Colour blindness	3
8	Multifactorial diseases 8.1 Hyperlipidemia 8.2 Atherosclerosis 8.3 Diabetes mellitus	3
9	Mitochondrial syndromes	1
10	Management of genetic disorders	3
11	Historical overview of genetic counseling 11.1 Models of Eugenic, Medical/Preventive, Decision making, Psychotherapeutic counseling; current definition and goals 11.2 Philosophy and ethos of genetic services and counseling	2
12	Components of genetic counseling 12.1 Indications and purpose 12.2 Information gathering and construction of pedigrees 12.3 Medical Genetic evaluation 12.3.1 Basic components of Medical History 12.3.2 Past medical history, social & family history 12.4 Physical examination 12.4.1 General and dysmorphology examination 12.4.2 Documentation	2
13	Patterns of inheritance, risk assessment and counseling in common Mendelian and multifactorial disorders	3
14	Biochemical and molecular genetic tests 14.1 In children 14.2 Presymptomatic testing for late onset diseases (predictive medicine)	2
15	Prenatal and pre-implantation diagnosis 15.1 Indications for prenatal diagnosis 15.2 Indications for chromosomal testing 15.3 Noninvasive methods	2

15.4 Invasive methods

16 Legal and ethical considerations 1

Recommended Books

1 Cox and Sinclair(1997). Molecular Biology in Medicine. Blackwell
2 DeGrouchy and Turleau (1984). Clinical Atlas on Human Chromosomes. Wiley
3 Jankowski and Polak (1996). Clinical Gene Analysis and Manipulation. Cambridge
4 Korf (1996). Human Genetics – A Problem Based Approach. Blackwell
5 Pasternak (2000). An Introduction to Molecular Human Genetics. Fritzgarald
6 Rasko and Downes (1995). Genes in Medicine. Kluwer
7 Rimoin et al (2002). Principles & Practice of Medical Genetics, vol I-III. Churchill
8 Robinson and Linden (1994). Clinical Genetics Handbook. Blackwell
9 Strachan and Read (1999). Human Molecular Genetics. Wiley
10 Wilson (2000). Clinical Genetics: A Short Course. Wiley-Liss
11 Baker et al (1998). A Guide to Genetic Counseling. Wiley
12 Harper (2001). Practical Genetic Counseling. Arnold
13 Rose & Lucassen(1999). Practical genetics of primary care. Oxford
14 Young (1999). Introduction to Risk Calculation in Genetic Counseling. Oxford

MGM303: Developmental Genetics Credits: 3

1 Early development 5

1.1 Fertilization
1.2 Types of cleavage
1.3 Gastrulation: Cell movement and formation of germ layers in frog, chick and mouse
1.4 Concept of determination, competence and differentiation

2 Development of vertebrate nervous system 5

2.1 Formation of neural tube
2.2 Formation of brain regions
2.3 Tissue architecture of the central nervous system

3 12

3.1 *Caenorhabditis*: Vulva formation
3.2 *Drosophila*

3.2.1 Maternal genes and formation of body axes
3.2.2 Segmentation genes
3.2.3 Homeotic genes function
3.2.4 Imaginal disc development

3.3 Vertebrates

3.3.1 Axes formation and HOX genes
3.3.2 limb formation in chick

4 Programmed rearrangements in genes 4

4.1 Chromatin diminution
4.2 Endoreplication cycles
4.3 Gene amplification

5 Genome imprinting 1

6 Genetic determination of sex in *Caenorhabditis*, *Drosophila* and mammals 3

7 Regeneration 1

8 Senescence 1

9 Embryonic stem cells and their applications 2

10 Clinical embryology 5

10.1 Differentiation of germ cells and gametogenesis
10.2 Fertilization and implantation
10.3 Stages of human embryonic development
10.4 Congenital malformations and teratogenesis
10.5 Reproductive failure and infertility and assisted reproduction

Recommended Books

1 Alberts et al (2007). Molecular Biology of The Cell. Garland
2 Gilbert (2006). Developmental Biology. Sinauer
3 Kalthoff (1996). Analysis of Biological Development. McGraw Hill
4 Lewin (2007). GenesIX. Pearson
5 Monk (1987). Mammalian Development – A Practical Approach. IRL
6 O'Rahilly and Muller (1992). Human Embryology and Teratology. Wiley
7 Rana (1998). Human Embryology Made Easy. Harwood
8 Wolpert (2007). Principles of Development. Oxford

MGM304: Immunogenetics **Credits: 3**

1 An introduction to immune system
1.1 Innate and adaptive immunity
1.2 Cells and organs of the immune system 7
1.3 Primary and secondary immune responses
1.4 Antigens, antibodies and T cell receptors

1.4.1 Antigens
1.4.2 Structure and function of immunoglobulins
1.4.3 Monoclonal antibodies
1.4.4 B and T cell receptors and coreceptors
1.4.5 Antigen-antibody interactions

2 Immunoglobulin and T-cell receptor genes 8
2.1 Organization of Ig gene loci
2.2 Molecular mechanisms of generation of antibody diversity
2.3 Expression of Ig genes
2.4 Regulation of Ig gene transcription
2.5 Antibody engineering
2.6 Organization of TCR gene loci
2.7 Generation of TCR diversity

3 The HLA complex 3
3.1 Organization of HLA complex
3.2 Structure of class I and II HLA molecules
3.3 Expression of HLA genes
3.4 HLA polymorphism

4 Generation and regulation of immune responses 12
4.1 Antigen processing and presentation
4.2 MHC-restriction
4.3 Cytokines
4.4 T Cell Maturation, activation and differentiation
4.5 B Cell Generation, Activation and differentiation
4.6 Clonal selection and immunological memory
4.7 Complement system
4.8 Leukocyte, Activation and Migration
4.9 Cell mediated cytotoxic responses
4.10 Regulation of immune responses
4.11 Immunological tolerance

5 Disorders of Human Immune System 5
- 5.1 Primary and secondary immunodeficiencies
- 5.2 Autoimmune disorders
- 5.3 Hypersensitive reactions
- 5.4 Cytokine-related diseases

6 Immune system in human health 4
- 6.1 Immune response to infectious diseases and malignancy
- 6.2 Concept of immunotherapy
- 6.3 Vaccines
- 6.4 Transplantation immunology

Recommended Books

1 Abbas et al (2007). Cellular and Molecular Immunology. Saunders
2 Barrett (1988). Text Book of Immunology. Mosloy
3 Benjamin et al (2003). Immunology – A Short Course. Wiley-Liss
4 Kuby (2006). Immunology. Freeman
5 Roitt (2003). Essential Immunology. Blackwell
6 Roitt et al (2001). Immunology. Mosloy

MGM305	Lab work based on courses MGM301 & MGM302	**Credits: 2**
MGM306	Lab work based on courses MGM303 & MGM304	**Credits: 2**

MGM307: Clinical Assignments Credits: 2

Each student will visit the BHU hospital as per the schedule drawn each year and undertake analysis of some of the inherited diseases presented during these visits. Each student will maintain a detailed record of the visits and the patients analyzed and submit a Report on the same.

MGM308M: Basic Genetics and Genetic Disorders Credits: 3

1 Mendelism and its extensions 7
- 1.1 Law of segregation
- 1.2 Law of independent assortment
- 1.3 Chromosomal basis of segregation and independent assortment
- 1.4 Linkage
- 1.5 Crossing over
- 1.6 Multiple allelism
- 1.7 Pleiotropy
- 1.8 Cytoplasmic inheritance

2 Cytogenetics 6
- 2.1 Chromatin structure
- 2.2 Heterochromatin and euchromatin
- 2.3 Mitosis
- 2.4 Meiosis
- 2.5 Dosage compensation
- 2.6 Chromosomal aberrations

3 Molecular Genetics 10
- 3.1 Nature of genetic material and flow of genetic information
- 3.2 DNA replication
- 3.3 Transcription
- 3.4 Translation
- 3.5 Genetic code
- 3.6 Regulation of gene expression

	3.6.1. Transcriptional regulation (Operon, Enhancers and promoters) 3.6.2. Post transcriptional regulation (Alternative splicing, gene silencing) 3.7 Transposable elements 3.8 DNA damage and repair 3.9 Mutation	
4	Human Molecular Genetics 4.1 Organization of human genome 4.2 Pedigree analysis 4.3 Monogenic and polygenic traits 4.4 Gene mapping and linkage analysis 4.5 Genetic counseling 4.6 Prenatal diagnosis	6
5	5.1 Molecular mechanisms of carcinogenesis 5.2 Oncogenes and tumour suppressor genes 5.3 Apoptosis and cancer	3
6	Genetic disorders 6.1 Inborn errors of metabolism: Phenylketonuria 6.2 Neurogenetic disorders: Alzheimer's disease 6.3 Muscle genetic disorders: Duchenne Muscular Dystrophy 6.4 Genetic disorders of Haematopoitic systems: Sickle cell anemia 6.5 Multifactorial disorders: Diabetes mellitus 6.6 Mitochondrial syndromes 6.7 Management of genetic disorders	7

Recommended Books

1 Strickberger (1985). Genetics. McMillan
2 Snustad & Simmons (2005). Principles of Genetics. Wiley
3 Griffiths et al (2002). Modern genetic analysis. Freeman
4 Hartl and Jones (1998). Genetics-Principles and Analysis. Jones & Bartlett
5 Nelson et al (2006). Lehninger's Principles of Biochemistry. McMillan
6 Alberts et al (2007). Molecular Biology of the Cell. Garland
7 Lewin (2007). Genes IX. Jones & Bartlett
8 Kasper et al (2005). Harrison's Principles of Internal Medicine. Vol. I & II. McGraw Hill
9 Strachan and Read (2003). Human Molecular Genetics. Wiley
10 Pritchard & Korf (2007). Medical Genetics at a glance. Wiley-Blackwell
11 Lodish et al (2004). Molecular Cell Biology. Freeman
12 Karp (2005). Cell and Molecular Biology. John Wiley
13 Rimoin et al (2002). Principles & Practice of Medical Genetics. Vol. I-III. Churchill
14 Weinberg (2006). Biology of Cancer. Garland

SEMESTER - IV

MGM401: Human Genome **Credits: 3**

1	The Genome project 1.1. History, organization and goals of human genome project 1.2. Mapping strategies, current status of various maps; DNA segment nomenclature 1.3. Human genome diversity	8
2	Organization of human genome 2.1. Mitochondrial genome 2.2. Gross base composition of nuclear genome 2.3. Gene density 2.4. CpG islands 2.5. RNA-encoding genes 2.6. Functionally identical/similar genes 2.7. Diversity in size and organization of genes 2.8 Annotation	8
3	Gene families 3.1 Multigene families – Classical gene families, families with large conserved domains, families with small conserved domains 3.2 Gene superfamilies 3.3 Gene families in clusters 3.4 Pseudogenes 3.5 Repetitive DNA and transposable elements 3.6 Origin of gene families	
4	Comparative Genomics 4.1 Overview of prokaryotic and eukaryotic genomes 4.2 C-value, number of genes and complexity of genomes 4.3 Conservation and diversity of genomes 4.4 Comparative genomics as an aid to gene mapping and study of human disease genes	8
5	Functional genomics 5.1 Transcriptome and its analysis 5.2 Proteome and Proteomics 5.3 gene silencing	5
6.	Disease and genomics	2

Recommended Books

1 Brown (2007). Genomes. Bios
2 Coleman and Tsongalis (1997). Molecular Diagnosis. Humana
3 Dale & Schartz (2003). From Genes to Genomes. Wiley
4 Hawley and Mori (1999). The Human Genome. Academic
5 Lewis (1999). Human Genetics. WCB
6 Liebler (2002). Introduction to Proteomics. Humana
7 Pasternak (2000). An Introduction to Molecular Human Genetics. Fritzgerald
8 Primrose & Twyman (2003). Principles of Genome Analysis & Genomics. Blackwell
9 Strachan and Read (2005). Human Molecular Genetics 3. Wiley
10 Sudbery (2002). Human Molecular Genetics. Prentice Hall
11 Alberts et al (2007). Molecular Biology of the Cell. Garland
12 Cowell (2001). Molecular Genetics of Cancer. Bios
13 Ehrlich (2000). DNA Alterations in Cancer. Eaton
14 Gersen & Keagle (1999). Principles of Clinical Cytogenetics. Humana
15 Lewin (2007). GenesI X. Pearson
16 Lodish et al (2004). Molecular Cell Biology. Freeman
17 Stillman (1994). Molecular Genetics of Cancer. CSHL

MGM402: Population & Evolutionary Genetics **Credits:3**

1	Concept and theories of evolution	3
2	Microevolution in Mendelian population 2.1 Mendelian Population 2.2 Allele frequencies and genotype frequencies 2.3 Hardy-Weinberg equilibrium and conditions for its maintenance	5
3	Elemental forces of evolution 3.1 Mutation 3.2 Selection (Types of selection, selection coefficient, selection in natural populations) 3.3 Genetic drift 3.4 Migration	6
4	Chromosomal, DNA and allozyme polymorphism in natural population 4.1 Adaptive genetic polymorphism 4.2 Balanced polymorphism and heterosis 4.3 Genetic coadaptation and linkage disequilibrium	5
5	Isolating mechanisms	3
6	Concept of species and modes of speciation: sympatric, allopatric, stasipatric	3
7	Molecular population genetics 7.1 Molecular evolution (neutral theory, punctuated equilibrium) 7.2 DNA-based phylogenetic trees 7.3 Molecular clock	4
8	Nonrandom breeding 8.1 Inbreeding and assortative mating 8.2 Path diagram construction and inbreeding coefficient, allelic identities by descent	3
9	Human phylogeny 9.1 Hominid evolution: anatomical, Geographical, Cultural 9.2 Molecular phylogenetics of Homo sapiens 9.3 Peopling of continents (Europe, Africa, Asia)10.	4
10	Population Substructure 10.1 Hierarchical population structure 10.2 Isolate breaking: The Wahlund principle	3

Recommended Books

1 Brown (2007). Genomes. Bios
2 Hartl & Clark (1997). Principles of Population Genetics. Sinaur
3 Hartl and Jones(1998). Genetics _ Principles and Analysis. Jones and Bartlet
4 Hoelzel (1998). Molecular Genetic Analysis of Populations. Oxford Univ
5 Jobling et al (2004). Human Evolutionary Genetics. Garland
6 Moody (1964). Evolution. Harper and Row
7 Roberts & DeStefano (1986). Genetic Variation and its Maintenance. Cambridge Univ
8 Smith (1998). Evolutionary Genetics. Oxford
9 Strickberger (2000). Evolution. Jones and Barlett

MGM403: Neurogenetics **Credits: 3**

1	Nervous system 1.1 Major regions of human brain 1.2 Cellular components of nervous tissue 1.3 Sub cellular organization of the nervous system 1.4 Membrane potential and action potential	12
2	Learning and memory	3
3	Circadian rhythms	2
4	Neurogenetic disorders 4.1 Spinomuscular atrophy	10

4.2 Syndromes due to triplet nucleotide expansion
4.3 Alzheimers disease
4.4 Parkinsons disease

5 Nature-nurture and behaviour 6

5.1 Genetic experiments to investigate animal behaviour

5.1.1 Selection studies
5.1.2 Inbred strain studies

5.2 Identifying genes for controlling behavior

5.2.1 Induced mutations
5.2.2 Quantitative trait loci
5.2.3 Synteny/orthology

5.3 Investigating the genetics of human behaviour

5.3.1 Twin and adoption study designs, interpreting heritability
5.3.2 Linkage and association studies
5.4 Environmental influence- shared and non-shared environment

6 Psychopathology 6

6.1 Schizophrenia
6.2 Mood disorders
6.3 Disorders of childhood

Recommended Books

1 Kaplan and Sadock (2007). Synopsis of Psychiatry. Williams & Wilkins
2 Plomin et al (2001). Behavioral Genetics. Freeman
3 Zigmond, Bloom et al., (2002). Fundamentals Neuroscience. Academic Press
4 Kandel, Schwartz et al. (2000). Principles of Neuroscience. Prentice Hall
5 Pasternak (2005). An Introduction to Molecular Human Genetics. Fritzgarald
6 Cox and Sinclair (1997). Molecular Biology in Medicine. Blackwell
8 Rasko and Downes (1995). Genes in Medicine. Kluwer
9 Rimoin et al(2002). Principles & Practice of Medical Genetics, vol I-III. Churchill
10 Robinson and Linden (1994). Clinical Genetics Handbook. Blackwell
11 Strachan and Read (2003). Human Molecular Genetics. Wiley
12 Wilson (2000). Clinical Genetics: A Short Course. Wiley-Liss

MGM L 404	Lab work based on course MGM401	**Credits: 2**
MGM L 405	Lab work based on courses MGM402 & MGM403	**Credits: 2**

MGM406: Dissertation (Credits: 6)

Each student will undertake an experimental project under supervision of one of the teachers during Semester 4 and submit TWO copies of the dissertation which will include: a) Review of the relevant literature, b) Objectives of the study, c) Materials and Methods, d) Results/Observations (supported by figures/tables etc as required), e) Discussion of the Results/Observations, f) Summary and g) References

MGM407: Comprehensive Viva-voice (Credits: 2)

MGM408: Seminar & Formulation of a Research Proposal (Credits: 2)

The student will deliver a comprehensive seminar on a current topic of his/her choice in the field of Molecular & Human Genetics. The topic of Seminar must be different from the topics covered in any of the courses.

M. Sc. PETROLEUM GEOSCIENCES
(Special Course of Study)
DEPARTMENT OF GEOLOGY
BANARAS HINDU UNIVERSITY

The initial intake shall be limited to ten seats through the B. H. U. Entrance Test. Students having passed Three Year and/or Six Semester B.Sc. (Hons.) Geology of BHU with Physics and Mathematics at + 2 level or any other equivalent examination of other universities shall be considered eligible for appearing at the Entrance Test. In view of the course being customized to the requirements of the hydrocarbon industry, the Department proposes to run the course as fully self financed with a fee structure of Rs. 50,000/- per semester.

The M.Sc. Petroleum Geosciences shall be imparted to students for two academic sessions consisting of four semesters as given below. Candidates will be examined and evaluated on grade basis at the end of each semester in the different courses of theory and practical as per credits given against each course. The M.Sc. Petroleum Geosciences will consist of (a) Core Courses, (b) Minor Elective Courses of other Departments, (c) Industrial Training at oil companies (4-6 weeks) and (d) Project Oriented Dissertation (periodic seminars, final presentation and thesis).

d) The Core courses will be compulsory for all the students admitted to M.Sc. Petroleum Geosciences. There will be twelve core courses, covering major branches of Geology, each of 3 credits, seven laboratory work of 2 credits, two seminar and viva-voce of 2 credits and one seminar and viva-voce of 3 credits. The Semesters – I, II and III shall include four courses each.

e) M.Sc. Petroleum Geosciences incorporates three compulsory minor elective courses of other Departments, one in each semester and each of 3 credits.

c) The industrial training includes four to six weeks training at oil companies of 10 credits in semester IV. Besides, there will be one 'inter semester winter geological field training in hydrocarbon prospective basin' in semester-I and one 'inter semester summer geological field training in hydrocarbon producing basin' in semester-II, each of 3 credits.

d) Along with the above courses, there shall be a Project Oriented Dissertation of 12 credits in semester-IV.

Marks for theory and practical examinations shall be as under:

Exam. Components	Marks for Semester Exam.	**Sessional** Intra Semester Test + class assignment and regularity	**Sessional** Intra-semester practical assessment + class assignment and regularity	Total Marks
Theory	70	30 (20+10)	-	100
Practical	70	-	30 (20+10)	100

Semesterwise distribution of Courtses and Credits

SEMESTER – I		
Course Code	**Title**	**Credits**
PGM101	Structural Geology and Tectonics	3
PGM102	Sedimentology and Sequence Stratigraphy	3
PGM103	Applicative Paleontology and Stratigraphy	3
PGM104	Fundamentals of Petroleum Geology	3
PGM105	Seminar and Viva Voce-I	2
PGM106	Practicals connected to PGM101	2
PGM107	Practicals connected to PGM102	2
PGM108	Practicals connected to PGM103	2
PGM109	Inter semester winter Geological Field Training in hydrocarbon perspective basin - I	3
#	Minor Elective *(from other PG Programmes)*	3
	TOTAL	**26**
SEMESTER - II		
PGM201	Seismic Data Processing and Basin Analysis	3
PGM202	Geophysical Exploration and Petrophysics	3
PGM203	Hydrocarbon Geochemistry	3
PGM204	Reservoir Study	3
PGM205	Seminar and Viva Voce - II	2
PGM206	Practicals connected with PGM201 & PGM202	2
PGM207	Practicals connected with PGM203	2
PGM208	Inter semester summer Geological Field Training in hydrocarbon producing basin - II	3
#	Minor Elective: *(from other PG Programmes)*	3
	TOTAL	**24**
SEMESTER - III		
PGM301	Well Site Geological Techniques	3
PGM302	Drilling and Production	3
PGM303	Economics, Policy and Managements	3
PGM304	Non-conventional Petroleum Exploration	3
PGM305	Seminar and Viva Voce – III	2
PGM306	Practicals connected with PGM301 & PGM 302	2
PGM307	Practicals connected with PGM304	2
#	Minor Elective: *(from other PG Programmes)*	3
	TOTAL	**21**
SEMESTER - IV		
PGM401	Industrial Training at Oil Companies	10
PGM402	Project Oriented Dissertation	12
	TOTAL	**22**
	GRAND TOTAL	**93**

M.Sc. Petroleum Geoscience students will opt 3 Minor Electives (3 credit each in semester I,II & III) offered by other PG Programmes of the Faculty.

SEMESTER - I

Course No. PGM101: STRUCTURAL GEOLOGY AND TECTONICS Credit: 3

Concept of stress and strain; Translation, rotation and deformation, kinematics and dynamic analysis, description of folds, joints, faults, unconformities and salt domes, mechanisms of the above structures; Cleavage, lineation and foliation; Stereographic projections of linear and planar structures, maps and cross sections; Structure contour maps, isopach maps and other facies maps, balanced cross-section, their importance in unraveling the geological history; Composition and internal structure of the earth, concept of plate tectonics and its role in hydrocarbon exploration.

Books Recommended:

Condie, Kent. C. (1982): Plate Tectonics and Crustal Evolution, Pergamon Press Inc.
Gass I.G. (1982): Understanding the Earth. Artemis Press (Pvt) Ltd. U.K.
Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Developments. Pergamon Press.
Hobbs, B.E., Means, W.D. and Williams, P.F. (1976): An outline of Structural Geology, John Wiley and Sons, New
York.
Ramsay, J.G. (1967): Folding and fracturing of rocks, McGraw Hill.
Ramsay, J.G. and Huber, M.I. (1983): Techniques of Modern Structural Geology, Vol. I, Strain Analysis, Academic Press.
Ramsay, J.G. and Huber, M.I. (1987): Techniques of Modern Structural Geology, Vol. II, Folds and Fractures, Academic Press.
Ramsay, J.G. and Huber, M.I. (2000): Techniques of Modern Structural Geology, Vol. III (Application of continuum mechanics), Academic Press.
Turner, F.J. and Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites, McGraw Hill.
Windlley B. (1973): The Evolving continents, John Wiley and Sons, New York.

Course No. PGM102: SEDIMENTOLOGY AND SEQUENCE STRATIGRAPHY Credit: 3

Introduction, scope of sedimentology; Processes of sedimentation and diagenesis; Classification of sedimentary rocks, textures of sediments and sedimentary rocks and their analysis; Interpretation of grain size data; Hydrodynamic conditions of sediment transportation and sedimentary structures; Statistical treatment of paleocurrent data; Mineralogy of sedimentary rocks (kinds of sedimentary particles); Heavy minerals and their relationships with provenance and plate tectonic setting.

Physical and chemical parameters of depositional environments, classification of environments, lithologs, structures and vertical sequences formed in alluvial, deltaic, coastal, deep sea and desert environments; Carbonate environments; Tectonics and sedimentation.

Sequence stratigraphy, its concept, evolution, order and duration, application and significance; Fundamentals of sequence stratigraphy, depositional sequence, sequence architecture, types and boundaries, condensation and starvation; Conformity and types of sequence unconformities; Flooding surface, maximum flooding surface, marine flooding surface; System tracts - lowstand system tract, transgressive system tract, transgressive surface and highstand system tract, overlap, offlap, toplap and onlap, aggradation, progradation, retrogradation, transgression and regression; Eustatic sea level changes; Outcrop, subsurface and offshore sequence stratigraphy and their integration; Seismic stratigraphy; Sequence stratigraphy in well sections and application of well logs; Sequence stratigraphic approach in basin analysis and case history of important petroliferous basins of India.

Books Recommended:

Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of sedimentary rocks, Prentice-Hall.
Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall.
Coe, Angela, Dan Bosence, Kevin Church, Steve Flint, John Howell and Chris Wilson (2002): The Sedimentary Record of Sea Level Change , Cambridge Univ. Press.
Collins, J.D., and Thompson, D.B. (1982): Sedimentary structures, George Allen and Unwin, London.
Emery, D, (1996): Sequence Stratigraphy, Blachwell Scientific Publ.
Lindholm, R.C. (1987) A practical approach to sedimentology, Allen and Unwin, London.
Miall, A.D. (1997): The Geology of Stratigraphic Sequence, Springer-Verlag.
Miall, A.D. (2000): Principles of basin analysis, Sjpringer-Verlag.
Pettijohn;, F.J. (1975): Sedimentary rocks (3rd Ed.), Harper and Row Publ.
Reading, H.G. (1997): Sedimentary environments and facies, Blackwell Scientific Publ.
Reineck, H.E. and Singh, I.B. (1980): Depositional sedimentary environments, Springer-Verlag.

Selley, R. C. (2000) Applied sedimentology, Academic Press.
Tucker, M.E. (1981): Sedimentary petrology: An Introduction, Wiley and Sons.
Tucker, M.E. (1990): Carbonate sedimentolgy, Blackwell Scientific Publ.

Course No. PGM103: APPLICATIVE PALEONTOLOGY AND STRATIGRAPHY Credit: 3

Paleontology – scopes, branches and applications; Important groups of mega and microfossils; Types of microfossils, their description and uses; Sampling, selected groups of microfossils - foraminifera, ostracods, bioherms – stromatolites, diatoms, cocoliths, spores and pollens.

Changing concepts in stratigraphy, basic principles of stratigraphy, stratigraphic classification, international code of stratigraphic nomenclature, correlation, graphic representation of stratigraphic data, principles of litho, bio, chrono, magnetic and seismic stratigraphy; Sequence stratigraphy, stratigraphic maps and relationships; Stratigraphy of the important petroliferous basins.

Books Recommended:

Alfred, T. (1988): Paleopalynology, Unwin Hyman.
Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontoogy, London.
Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988): Fossil Invertebrates, Blackwell.
Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall.
Clarksons, E.N.K. (1998): Invertebrate Paleontology and Evolution, Allen and Unwin, London.
Dobzhansky, Ayala, Stebbins and Valentine (1977): Evolution, Freeman.
Doyle, P. and Bennett. M.R. (1996): Unlocking the stratigraphic Record, John Wiley and Sons.
Horowitz, A.S. and Potter, E.D. (1971): Introductory Petrography of Fossils, Springer Verlag.
Jones, T.P. and Rowe, T.P. (1999):Fossil Plants and Spores, Modern techniques, Geological Soc. of London.
Krishnan,M.S. (1982): Geology of India and Burma, C.B.S. Publ.
Kumar, R. (1985): Historical Geology and Stratigraphy of India, Wiley Eastern Ltd.
Lehmann, U. (1983): Fossils Invertebrate, Cambridge Univ. Press.
Mayr, E. (1971): Population, Species and Evolution, Harvard.
Moore, R.C., Lalicker, C.G. and Fischer, A.G.(1997): Invertebrate Fossils, CBS Publ.
Nield, E.W. and Tucker, V.C.T. (1985): Palaeontology: An Introduction, Pergmon Press.
Pascoe, E.H. (1968): A Manual of the Geology of India and Burma (Vols.I-IV), Govt. of India Press, Delhi.
Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
Raup, D.M. and Stanley, S.M. (1985): Principles of Paleontology ,CBS Publ..
Schoch, Robert, M. (1989): Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.
Smith, A.B.(1994): Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
Strean, C.W. and Carroll, R.L. (1989): Paleontology – the record of life, John Wiley.

Course No. PGM104: FUNDAMENTALS OF PETROLEUM GEOLOGY Credit: 3

Introduction, occurrence, surface indications and direct detection of hydrocarbons; Origin, generation, migration and accumulation of oil and gas; Physical properties of reservoir rocks; Petroleum traps, seals and fluids; Petroleum habitats; An outline of the oil belts of the world;

Books Recommended:

Barker, C. (1996): ThermalMmdeling of Petroleum Generation, Elsevier Science.
Holson, G.D. and Tiratso, E.N. (1985): Introduction of Petroleum Geology, Fulf Publ. Houston.
Hunt, J.M. (1996): Petroleum geochemistry and geology (2nd Ed.), Freeman, San Francisco.
Jahn, F., Cook, M. and Graham, M.(1998):Hydrocarbon Exploration and Production, Eslevier Science.
Makhous, M. (2000): The Formation of Hydrocarbon Deposits in North African Basins, Geological and Geochemical
Conditions, Springer–Verlag.
North, F.K. (1985): Petroleum Geology, Allen Unwin.
Selley, R.C. (1998): Elements of petroleum geology, Academic Press.
Tissot, B.P. and Welte, D.H. (1984): Petroleum formation and occurrence, Springer–Verlag.

Course No. PGM105: SEMINAR AND VIVA-VOCE - I **Credit:2**

Course No.: PGM106: PRACTICALS (connected to PGM101) **Credit:2**

Preparation and interpretation of geological maps and sections, structural problems based on orthographic and stereographic projections of linear and planar structures; Recording and plotting of field data; Study of the hand specimen of deformed structures, preparation of geotectonic maps.

Course No.: PGM107: PRACTICALS (connected to PGM102) **Credit: 2**

Detailed study of clastic and non-clastic rocks in hand specimens; Study of assemblages of sedimentary structures in context of their palaeoenvironmental significance; Microscopic examination of important rock-types; Heavy mineral separation; their microscopic characters, graphic representation and interpretation; Grain-size analysis by sieving method; Plotting of size-distribution data as frequency and cumulative; Curves, computation of statistical parameters and interpretation; Exercises on sequence stratigraphic framework.

Course No.: PGM108: PRACTICALS (connected to PGM103) **Credit: 2**

Study of the morphological characters of some important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and Corals; Study of an assorted group of trace fossils; Techniques of separation of microfossils from matrix; Types of micrtofossils - calcareous, siliceous, phosphatic and organic walled microfossils; SEM applications in micropaleontology; Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India; Important palynomorphs of Cretaceous and Paleogene age; Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities.

Course No. PGM109: INTER SEMESTER WINTER GEOLOGICAL FIELD TRAINING IN HYDROCARBON PRSOPECTIVE BASIN- I **Credit: 3**

Course No. # : MINOR ELECTIVE (for other P. G. Programmes) **Credit: 3**

SEMESTER - II

Course No. PGM201: SEISMIC DATA PROCESSING AND BASIN ANALYSIS **Credit: 3**

Theory and geometry of seismic wave propagation, seismic wave velocities in rocks, synthetic seismogram and well to seismic tie, seismic interpretation – typical trap types and their seismic definition, velocity, structural and timing effects, preparation of depth map from time horizons; Basic concepts, definitions and objectives of seismic stratigraphy, stratigraphic patterns in seismic data, seismic attribute analysis, seismic sequence analysis - interpretation of depositional environment and lithology, eustatic sea level changes, seismic facies analysis-seismic reflection characteristics, simple and complex reflection configuration, seismic reflection character analysis- amplitude and continuity, seismic attribute extraction and analysis; Introduction to 3D volume based interpretation.

Course No. PGM202: GEOPHYSICAL EXPLORATION AND PETROPHYSICS **Credit: 3**

Theory of gravity and magnetic exploration methods; Historical development and background of refraction and reflection methods; Difference between refraction and reflection surveys; System of observation for reflection and refraction surveys. Refraction data interpretation for two horizontal and dipping layer case; Seismic data enhancement and test showing explosive and non-explosive; Sources of seismic energy for P-wave; Special weathering shots and noise analysis, elevation, weathering and dynamic corrections to refraction and reflection data; Random and non-random noises and their eliminations; Processing of seismic data; Migration techniques (classical and modern); Pitfalls of seismic interpretations; Interpretation of geology from this data; Basic concepts of seismic data acquisition in 2D and 3D patterns; VSP data acquisition, processing and utilization concepts; Introduction to the electrical and electro-magnetic methods; Petro-physical properties of rocks.

Books Recommended:

Amadei, B (1997): Rock stress and its measurement, Champman and Hall, London.
Guegen, Y. and Palciauskas, V. (1994): Introduction to physics of rocks, Princeton Univ. Press.
Hardage, B. A. (1987): Seismic stratigraphy, Elsevier, Amsterdam.

J. C. and Cook, N.G.W. (1979): Fundamentals of rock mechanics (3rd Ed.), Champman and Hall, London.
Payton, C. E. (1977): Seismic stratigraphy – Applications to Hydrocarbon Exploration, Memoir of the American Association of Petroleum Geologists, Vol. 26.
Sheriff, R.E. and Geldart, L.P. (1995): Exploration seismology (2nd Ed.), Cambridge Univ. Press.
Tiab, D. and Donaldson, E.C. (1996): Petrophysics – Theory and Practice of Measuring Reservoir Rock and Fluid Transport Properties, Gulf Publ. Co., Houston.
Yillmaz, O. (2001): Seismic data analysis: Processing inversion and tnterpretation of seismic data (Vol. 1 and 2), Society of Exploration Geophysicists, Tulsa, Oklahoma.

Course No. PGM203: HYDROCARBON GEOCHEMISTRY Credit: 3

Carbon cycle, origin composition and structure of organic matter, organic matter accumulation, maturation process and generation of hydrocarbons (oil and natural gas); Optical and geochemical methods for source rock characterization and maturation assessment; Coals, oil shales and other terrestrial source rocks for hydrocarbon generation; Modeling petroleum generations, migration and accumulation; Abnormal pressures; Soil analysis of surface seepages of oil and gas and surface geochemical exploration, Geochemical programme for petroleum exploration; Biomarkers and source rock-oil correlation, oil-oil correlation using biomarkers; Petroleum system; Prospect evaluation.

Books Recommended:

Bordenave, M.L. (Ed.) (1993): Applied Petroleum Geochemistry, Editions Technip, Paris.
Peters, K.E., Walters, C.C., Moldowan, J .M. (2005): The Biomarker Guide (Vol.1 and 2), Cambridge Univ. Press.
S. A. Tedesco (1994): Surface Geochemistry in Petroleum Exploration, Springer-Verlag.
Tissot, B.P., Welte, D. H. (1984.): Petroleum Formation and Occurrence, Springer-Verlag.
Welte, D.H., Horsfield, B., Baker, R. (1997): Petroleum and Basin Evolution: Insights from Petroleum Geochemistry, Geology and Basin Modeling, Springer-Verlag.

Course No. PGM204: RESERVOIR STUDY Credit: 3

Carbonate reservoirs, deep water sandstone (turbidites) reservoirs, sandstone reservoirs, reservoir fluids, phase behaviour, reservoir pressure measurement and its significance, reservoir drive mechanisms; Concept of surface tension, wet ability, capillary, oil, water and gas saturations, fluid displacement etc; Calculation of reservoir parameters from well logs; Estimation of hydrocarbon reserves, classification of reserves; Development of oil and gas field. Recovery of hydrocarbon; Enhanced oil recovery /improved oil recovery; Reservoir management, well test analysis and pressure transient studies, bore hole studies and their importance.

Books Recommended:

Berg, R.R. (1986): Reservoir Sandstones, Prentice Hall.
Moore, C. H. (2001): Carbonate Reservoirs, Elsevier, Amsterdam.
Barwis, J.H. (1990): Sandstone Petroleum Reservoir, Springer-Verlag.
Zimmerle, W. (1995): Petroleum Sedimentology, Kluwer Academic Publ.

Course No. PGM205: SEMINAR AND VIVA-VOCE - II Credit: 2
Course No.: PGM206: Practicals (connected with PGM201 & PGM202) Credit: 2

Study of seismic maps; Identifications and correlation of seismic markers, preparation of time maps and depth maps.

Course No.: PGM207: Practicals (connected with PGM203) Credit: 2

Megascopic and microscopic study of cores; Preparation of geological maps and sections, and derivation of geological history in relation to petroleum prospects; Calculation of oil reserves; Exercise on maturation studies; Petrographic characterization of petroleum source rocks.

Course No. PGM208: INTER SEMESTER SUMMER GEOLOGICAL FIELD TRAINING IN HYDROCARBON PRODUCING BASIN - II Credit: 3

SEMESTER - III

Course No. PGM301: WELL SITE GEOLOGICAL TECHNIQUES Credit: 3

Introduction, status of wells, geotechnical order, drilling methods, drilling fluids, cutting and core analysis, mud logging unit, sub-surface pressures, electro-logging (SP. GR. Resistivity, Neutron-density, Dipmeter, etc); Formation evaluation; Casing and cementation, drilling completions, formation testing, well completion, fundamental of reservoir, engineering and stimulation, documentation; Off-shore technology.

Books Recommended:

Asquith, G. and Gibson, C. (1982): Basic Well Log Analysis for Geologists, Academic Press.
Bateman, R. M. (1985): Open Hole Log Analysis and Formation Evaluation, Reidel, Dordrecht.
Gupta, P. K. and Nandi, P. K. (1995): Wellsite Geological Techniques and Formation Evaluation: A user's manual, Vol. Oil and Natural Gas Corporation, Dehradun.
Ransom, R.C. (1995): Practical Formation Evaluation, John Wiley and Sons.
Rider, M.H. (1985): The Geological Interpretation of Well Logs, Blackie, London.
Sera, O. (1984): Fundamentals of Well Log Interpretation, Vol. 1 and 2, Elsevier, Amsterdam.
Serra, O. (2003): Well Logging and Geology, Editions Technique Paris.
Whittaker, A. (1991): Mud Logging Handbook, Prentice Hall.

Course No**.** PGM302: DRILLING AND PRODUCTION Credit: 3

Drilling methods and equipment for directional, horizontal and multilateral wells; Geologic considerations in producing operations, reservoir considerations in well completion, well testing, primary cementing, well completion design, tubing strings, packers, surface control equipment, perforating oil and gas wells; Well completion and work over fluids. problem well analysis, through tubing production logging, squeeze cementing – remedial cementing, sand control, formation damage, surfactants for well treatments, acidizing, hydraulic fracturing, scale deposition, removal and prevention, corrosion control, work over jobs and work over planning.

Books Recommended:

Baker, R. (2001): A Primer of Oil Preparation of SP and Resistivity Logs for Hydrocarbon Reservoirs, Well Drilling: A basic text of oil and gas drilling, petroleum extension service, University of Texa.
Chilinger, G.V. and Vorabutr, P. (1981): Drilling and Drilling Fluids. Elsevier Science.
Hyne, N.J. (2001): Nontechnical Guide to Petroleum Geology, Exploration, Drilling and Production (2nd Ed.), Pennwell Co., Oklahoma.
Nguyen, J.P. (1996): Drilling, Editions Technique, Paris.

Course No. PGM303: ECONOMICS, POLICY AND MANAGEMENTS Credit: 3

Defining 'reserves', operating expenses, capital expenditures, inflation, factors affecting oil and gas prices, cash flow techniques, economic criteria - hurdle rate, time value of money, selection, ranking criteria, risk, uncertainty - types of risk, mathematical techniques, probabilistic models, uncertainty in economic analysis; Financing, ownership in the oil and gas industry - business arrangements between operators, between mineral owners; Accounting versus cash flow - accounting principles and definitions, differences between accounting cash numbers, depreciation, depletion, amortization; Budgeting - types, processes, selecting of projects for the budget, economic analysis of operations, computer economics software, tips on economic factors in computer spreadsheet analysis, ethics in economic analyses.

New exploration licensing policies (nelp) - implementation of nelp – speculative surveys, review/reassessment studies of fields including reserves, preparation of data packages. basic ideas of bidding, etc., monitoring of blocks, approvals/review – development plans, appraisal programme, annual work programme and budgets (be and re) monitoring of safety and environment aspects under psc – regular safety and environment audits and their compliance are carried out for companies operating under production sharing contract, e.i.a., iso certification, project management process; Manpower resources. Project- risk management, quality management in projects, communications, organization, team management; Case studies and exercises.

Books Recommended:

Carlo Danl (2004): International Energy Markets: understanding pricing, policies and profits, Pennwell Co.
D. Johnston (2003): International Exploration Economics, Risk and Contract Analysis, Pennwell Co.
Ian Lerche and James A. Mackay (1999): Economic Risks in Hydrocarbon Exploration, Pennwell Co.

Jim Bush and Daniel Johnston (2003): International Oil Company Financial Management in Non-technical language, Pennwell Co.
John Orban (2006): Money in the Ground, Meridian Press.
Lawrence J. Drew (1997): Undiscovered Petroleum and Mineral Resources: Assessment and Controversy, Plenum Press.
P. M. Harris and L. J. Weber (2006): Giant Hydrocarbon Reservoirs of the World, AAPG Memoir no. 88.
R. Hannessom (2001): Investing for Sustainability: The management of mineral wealth, Springer-Verlag.
Richard Barry (1993): The Management of International Oil Operations, Pennwell Co.
T. Aven and J. E., Vinnem (2007): Risk Management with Application from the Offshore Petroleum Industry, Springer-Verlag.

Course No. PGM304: NON-CONVENTIONAL PETROLEUM EXPLORATION Credit: 3

Coal bed methane - definition, origin of coal bed methane, geological controls of methane generation from coal; Physical , optical and chemical characterization of coal; Global coal bed methane potentials, reserves, CBM exploration and exploitation, environmental problem-water quality and utilization, CBM policy/ regulations; Underground coal gasification - definition, concept, development of UCG to date, implications of burning UCG, estimation of coal reserves for UCG, environmental benefits of UCG, global potential areas, UCG process, advantages, policy on UCG; Gas hydrates - definition, structures, compositions, world occurrences, exploration methods, potential locations on Indian off-shores, environmental impacts and future prospects; Tar sands and oil shales; Occurrences, exploration and exploitations.

Books Recommended:

Chandra, D., Singh, R.M. Singh, M. P. (2000): Textbook of Coal (Indian context), Tara Book Agency.
Gayer,R. and Harris, I. (1996): Coal Bed Methane and Coal Geology, Geological Soc. Special Publ., London.
Singh, M.P. (Ed.) (1998): Coal and Organic Petrology, Hindustan Publ. Co.
Stach;, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R.(1982): Stach Texbook of Coal Petrology, Gebruder Borntraeger, Stuttgart.
Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert P. (1998): Organic Petrology, Gebruder Borntraeger, Stuttgart.
Thomas, Larry (2002): Coal Geology, John Wiley and Sons.
Van Krevelen, D. W. (1993): Coal (typology-physics-chemistry-constitution), Elsevier Science.

Course No. PGM305: SEMINAR AND VIVA-VOCE - III Credit: 3

Course No. PGM306: Praticals (connected with PGM301 & 302) Credit: 2

Study of drill cores; Preparation and interpretation of SP, resistivity and other logs for hydrocarbon reservoirs; Exercise on formation evaluation.

Course No. PGM307: Praticals (connected with PGM304) Credit: 2

Macroscopic characterization of banded coals; Completion of outcrop in the given maps and calculation of coal reserve; Preparation of polished particulate mounts of coal; Microscopic examination of polished particulate mounts (identification of macerals).

Course No. # : MINOR ELECTIVE (from other P.G. Programme) **Credit: 3**

SEMESTER - IV

Course No. PGM401: INDUSTRIAL TRAINING AT OIL COMPANIES Credit: 10
This includes Industrial Training at oil companies of 4 to 6 weeks duration.

Course No. PGM402: PROJECT ORIENTED DISSERTATION Credit: 12

This includes periodic seminars, final presentation and thesis.

M. Sc. PHYSICS
DEPARTMENT OF PHYSICS
BANARAS HINDU UNIVERSITY

Semesterwise distribution of Courses and Credits

SEMESTER – I

COURSE	TITLE	CREDITS
MPC-101:	MATHEMATICAL PHYSICS	4
MPC-102:	COMPUTATIONAL PHYSICS	3
MPC-103:	QUANTUM MECHANICS-I	4
MPC-104:	SEMICONDUCTOR DEVICES, INTEGRATED CIRCUITS AND COMMUNICATIONS	3
MPME-101*:	BASIC CONCEPTS IN PHYSICS: SMALL TO LARGE SYSTEMS	3
MPL-101:	ELECTRONICS LABORATORY	4
OR		
MPL-102:	GENERAL PHYSICS & OPTICS LABORATORY	4
MPL-103:	COMPUTATIONAL PHYSICS AND PROGRAMMING LABORATORY	2

*** Not for M.Sc. Physics students**

SEMETER – II

MPC-201:	CLASSICAL ELECTRODYNAMICS AND PLASMA PHYSICS	4
MPC-202:	ATOMIC, MOLECULAR PHYSICS AND LASERS	3
MPC-203:	ELEMENTS OF SOLID STATE PHYSICS	3
MPC-204:	ELEMENTS NUCLEAR PHYSICS	3
MPME-201:	APPLIED RADIATION PHYSICS	3
MPL-202:	GENERAL PHYSICS & OPTICS LABORATORY	4
OR		
MPL-201:	ELECTRONICS LABORATORY	4
MPL-203:	COMPUTATIONAL PHYSICS AND PROGRAMMING LABORATORY	2

SEMESTER - III

COURSE	TITLE	CREDITS
MPC–301:	STATISTICAL MECHANICS I	4
MPC–302:	QUANTUM MECHANICS II	3
MPS–301(A):	ANALOG COMMUNICATION SYSTEMS	4
MPS–301(B):	NUCLEAR PHYSICS:INTERACTIONS & MODELS	4
MPS-301(C):	VIBRATIONAL & ROTATIONAL MOLECULAR SPECTROSCOPY	4
MPS-301(D):	SOLID STATE PHYSICS: CRYSTALLOGRAPHY AND IMPERFECTIONS IN CRYSTALS	4
MPME-301:	EXPERIMENTAL TECHNIQUES FOR ANALYTICAL STUDIES	3
MPE-301:	PLASMA PHYSICS AND SPACE PHYSICS	3
MPE-302:	LASERS AND LASER APPLICATIONS	3
MPE–303:	CHARACTERIZATION OF SOLIDS	3
MPE–304:	MOLECULAR BIOPHYSICS	3
MPE–305:	METHODS IN THEORETICAL PHYSICS	3
MPE-306:	INSTRUMENTATION IN NUCLEAR PHYSICS	3
MPE-307:	SOLAR ENERGY, HYDROGEN ENERGY AND OTHER RENEWABLE ENERGIES	3
MPL-301(A):	ELECTRONICS LABORATORY	6
MPL-301(B):	NUCEAR PHYSICS LABORATORY	6
MPL-301(C):	SPECTROSCOPY LABORATORY	6
MPL-301(D):	SOLID STATE PHYSICS LABORATORY	6

SEMESTER – IV

COURSE	TITLE	CREDITS

MPC-401:	**STATISTICAL MECHANICS II**	**3**
MPS-401(A):	**DIGITAL COMMUNICTION SYSTEMS**	**4**
MPS-401(B):	**PARTICLE PHYSICS**	**4**
	MPS-401(C):MOLECULAR ORBITAL THEORY & ELECTRONICS SPECTRA OF MOLECULES	**4**
MPS-401(D):	**SOLID STATE PHYSICS: SOLID SURAFACES & PROPERTIES**	**4**
MPS-402(A):	**MICROPROSCESSORS AND INTERFACING**	**4**
MPS-402(B):	**WEAK INTERACTIONS & ELECTROWEAK UNIFICATION**	**4**
MPS-402(C):	**PRINCIPLES & INSTRUMENTATION IN CONVENTIONAL & LASER SPECTROSCOPY**	**4**
MPS-402(D):	**SOLID STATE PHYSICS: MANY PARTICLE SYSTEMS**	**4**
MPE-401:	**EXPERIMENTAL TECHNIQUES & INSTRUMENTATION IN ATOMIC, MOLECULAR & OPTICAL PHYSICS**	**3**
MPE–402:	**NANOSCIENCE AND TECHNOLOGY**	**3**
MPE-403:	**PHYSICS OF ELECTRONIC MATERIALS & DEVICES**	**3**
MPE-404:	**SATELLITE COMMUNICATION & REMOTE SENING**	**3**
MPE-405:	**QUANTUM FIELD THEORY:PATH INTEGRAL APPROACH**	**3**
MPE-406:	**LIQUID CRYSTAL**	**3**
MPE-407:	**COMPUTATIONAL METHODS IN PHYSICS**	**3**
MPL-401(A):	**ELECTRONICS LABORATORY**	**6**
MPL-401(B):	**NUCLEAR PHYSICS LABORATORY**	**6**
MPL-401(C):	**SPECTROSCOPY LABORATORY**	**6**
MPL-401(D):	**SOLID STATE PHYSICS LABORATORY**	**6**
MPD-401:	**DISSERTATION**	**2**

SUMMARY OF M.Sc. SYLLABUS IN PHYSICS

Semester	No. of Papers			Credits		
	Theory	Practical	Total	Theory	Practical	Total
I	5	2	7	17	6	23
II	5	2	7	16	6	22
III	5	1	6	17	6	23
IV	4	1	5	14	6	20
Dissertation						2
Total	19+ Dissertation	6	25	64	24	90

MINOR ELECTIVES:

SEMESTER:	**PAPER NO. AND TITLE**		**CREDITS**
I	MPME-101:	BASIC CONCEPTS IN PHYSICS: SMALL TO LARGE SYSTEMS	3
II	MPME-201:	APPLIED RADIATION PHYSICS	3
III	MPME-301:	EXPERIMENTAL TECHNIQUES FOR ANALYTICAL STUDIES	3

SEMESTER – I

MPC-101: MATHEMATICAL PHYSICS **Credits: 4**

Theory of Functions of a Complex Variable:
Analyticity and Cauchy-Reimann Conditions, Cauchy's integral theorem and formula, Taylor's series and Laurent's series expansion, Zeros and singular points, Multivalued functions, Branch Points and Cuts, Reimann Sheets and surfaces, Residues, Cauchy's Residue theorem, Jordan's Lemma; Evaluation of definite integrals, Principal Value, Bromwitch contour integrals.

Fourier and Laplace Transforms:
Fourier transform, Sine, Cosine and Complex transforms with examples, Definition, Properties and Representations of Dirac Delta Function, Properties of Fourier Transforms, Transforms of derivatives, Parseval's Theorem, Convolution Theorem, Momentum representation, Applications to Partial differential equations, Discrete Fourier transform, Introduction to Fast Fourier transform, Laplace transform, Properties and examples of Laplace Transform, Convolution theorem and its applications, Laplace transform method of solving differential equations.

Group Theory:
Concept of a group (additive and multiplicative), Matrix representation of a group, Reducible and irreducible representation of a group,The Great Orthogonality Theorem

Reference Books:

1. Mathematical Methods for Physicists: Arfken.
2. Mathematics for Physicists and Engineers: Pipes.
3. Mathematical Method of Physics Ghatak.
4. Mathematical Methods for Physics: Wyle.
5. Mathematical Methods in Physical Sciences: Boas.
6. Group Theory: Wigner

MPC-102: COMPUTATIONAL PHYSICS AND PROGRAMMING **Credits: 3**

Fortran:
Flow charts, Algorithms, Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements, Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitive and logical structures, Subroutines and functions, Operation with files, Operating systems, Creation of executable programs.

Numerical Methods of Analysis:
Solution of algebraic and transcendental equations: Iterative, bisection and Newton-Raphson methods, Solution of simultaneous linear equations: Matrix inversion method, Interpolation: Newton and Lagrange formulas, Numerical differentiation, Numerical Integration, Trapezoidal, Simpson and Gaussian quadrature methods, Least-square curve fitting, Straight line and polynomial fits, Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods.

Simulation:
Generation of uniformly distributed random integers, Statistical tests of randomness, Monte-Carlo evaluation of integrals and error analysis, Non-uniform probability distributions, Importance sampling, Rejection method, Metropolis algorithm, Molecular diffusion and Brownian motion as random walk problems and their Monte-Carlo simulation.

Reference Books:

1. Computational Methods in Physics and Engineering: Wong.
2. Computer Oriented Numerical Methods: Rajaraman.
3. Computer Programming in FORTRAN 77: Rajaraman.
4. Applied Numerical Analysis: Gerald.
5. A Guide to Monte Carlo Simulations in Statistical Physics: Landau and Binder.
6. Numerical Recipes: Teukolsky, Vetterling and Flannery.

MPC-103: QUANTUM MECHANICS –I **Credits: 4**

Linear Vector and Representation Theory:
Linear vector space, Dirac notations of Bra - Ket notation, Matrix representation of Observables and states, Determination of eigenvalues and eigenstate for observables using matrix representations, Change of representation and unitary transformations, Coordinate and momentum representations, Equations of motion in Schroedinger and Heisenberg pictures.

Theory of Angular Momentum:
Symmetry, invariance and conservation laws, relation between rotation and angular momentum, commutation rules, Matrix representations, addition of angular momenta and Clebsch-Gordon coefficients, Pauli spin matrices.

Green's Functions:
Green's function method of solving inhomogeneous differential equations, Boundary Conditions, Application to One-dimensional problems.

Scattering Theory:
Differential and total Scattering cross-sections laws, partial wave analysis and application to simple cases; Integral form of scattering equation, Born approximation validity and simple applications.

Approximation Methods:
Time-independent Perturbation theory (non-degenerate and degenerate) and applications to fine structure splitting, Zeeman effect (Normal and anomalous), Stark effect, and other simple cases, Variational method and applications to helium atom and simple cases; WKB approximation and applications to simple cases. Time-dependent Perturbation theory, Fermi's Golden rule, Semi-classical theory of interaction of atoms with radiation.

Reference Books:

1. Quantum Mechanics: L.I. Schiff.
2. Modern Quantum Mechanics: J.J. Sakurai.
3. Introduction to Quantum Mechanics : C.J. Joachain and B.H. Bransden.
4. Introduction of Quantum Mechanics: D.J. Griffiths.
5. Principles of Quantum Mechanics: P.A.M.Dirac.

MPC-104: SEMICONDUCTOR DEVICES INTEGRATED CICUITS AND COMMUNICATIONS **Credits: 3**

Semiconductor Devices:
Metal/Semiconductor Contact, MOS Junction (Accumulation, Depletion and Inversion).

Integrated Circuits:
Fabrication of ICs (Planar, Monolithic, Active and Passive Including MOS).

Op-Amp (IC-741):
Internal Structure (Block Diagram) Slew Rate, Frequency Response and Compensation, Applications (Linear and Non- Linear).

Timer (IC-555):
Internal Structure (Block Diagram) Operation, Astable, Monostable and Applications.

Phase Locked Loops (IC-565):
Internal Structure (Block) Diagram) Application as Frequency Multiplication, Division FSK and FM Demodulation.

Digital ICs:
TTl, MOS and CMOS Gates, Parrallel Binary adder/subtractor, BCD Addition/Subtraction, Encoder, Decoder, MUX, DE-MUX, Flip-Flops, Shift Resister, Counter, Memory Concept, RAM and ROM. Introduction to Microprocessor 8085.

Communication:

Radio Wave Propagation through Ground, Stratosphere and Ionosphere. Radiation from short electric doublet. Monopole and Dipole Antenna, Antenna parameters, Antenna Arrays.

Reference Books:

1. Integrated Electronics: Millman and Halkias.
2. Physics of Semiconductors Devices: Sze.
3. Op-Amps and Linear Integrated Circuits: Gayakwad.
4. Digital Fundamental: Floyed.
5. Electronic Communication Systems: Kennedy
6. Linear Integrated Circuits: Choudhary and Jain.
7. Digital Electronics: Jain.

MPME-101: General Concepts in Physics: Large to Small Bodies **Credit 3**

(This minor elective is open for M.Sc. students of other departments only)

Introduction

Historical Development of Physics; Classification of physics in terms of Length scales, Time scales and Energy scales.

Physics of Large Bodies

Evolution of universe and formation of stars. Newton's law of Gravitation; Planetary motion and Kepler's laws; Galilean relativity and concept of inertial frames. Einstein's theory of special relativity.

Physics of Small Bodies

Failure of classical ideas with examples of blackbody spectrum and Photoelectric effect; Heisenberg's Uncertainty Principle; Wave-particle duality. Double-slit experiment, Stern-Gerlach experiment. Concepts of discrete energy levels and spin. Elementary ideas of Schroedinger's Wave mechanics. Relation between Spin and Statistics; Bose-Einstein and Fermi-Dirac statistics, and Maxwell-Boltzmann statistics as classical limit. Elementary Particles (classification, quantum numbers) and Fundamental Interactions (classification, range, strength).

Reference Books:

1. Remarkable Physicists: From Galileo to Yukawa
2. The Feynman Lectures on Physics
3. Concepts of Modern Physics
4. University Physics

MPL-101: ELECTRONICS LABORATORY **Credits: 4**

Students assigned the electronics laboratory work will perform at least eight (08) experiments of the following:

1. Addition, Subtraction and Binary to BCD conversion
2. JK Flip-Flop and up-down counter
3. Transmission Line Experiment
4. Negative Feedback Experiment
5. Multivibrator
6. Differential Amplifier
7. Op-amps and its application
8. IC 555 Timer
9. Design of CE Amplifier
10. Design of Regulated Power Supply
11. Arithmetic Logic Unit
12. Receiver characteristics

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-102: GENERAL PHYSICS & OPTICS LABORATORY **Credits: 4**

Students assigned the general laboratory work will perform at least eight (08) experiments of the following:

1. Ionization potential of Lithium
2. Zeeman Effect
3. Dissociation Energy of I_2 molecule
4. Hall Effect
5. Four Probe Method
6. Electron Spin Resonance
7. Telexometer
8. Experiment on high intensity monochromator
9. Faraday Effect
10. Frank-Hertz experment
11. Compton Effect
12. Atomic Spectra of two-Electron Systems

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-103: COMPUTATIONAL PHYSICS & PROGRAMMING LABORATORY **Credits: 2**

Students assigned the computer laboratory work will perform in Semester - I at least four (04) experiments of the following:

1. Jacobi Method of Matrix Diagonalization
2. Solution of transcendental or polynomial equations by the Newton Raphson method
3. Linear curve fitting and calculation of linear correlation coefficient
4. Matrix summation, subtraction and multiplication
5. Matrix inversion and solution of simultaneous equation
6. Lagrange interpolation based on given input data
7. Numerical integration using the Simpson's method
8. Numerical integrationg using the Gaussian quadrature method
9. Solution of first order differential equations using the Rung-Kutta method
10. Numerical first order differentiation of a given function
11. Fast Fourier Transform
12. Monte Carlo integration
13. Use of a package for data generation and graph plotting.
14. Test of randomness for random numbers generators

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

SEMESTER – II

MPC-201: CLASSICAL ELECTRODYNAMICS AND PLASMA PHYSICS **Credits: 4**

Electrodynamics:

Four Potential and Four Field:
Electromagnetic field Tensor in Four dimensions and Maxwell's Equations, Dual Filed Tensor. Wave Equation for Vector and Scalar Potential and Solution, Retarded Potential and Lienard Wiechert Potential.

Acceleration of Charged Particles:
Electric and Magnetic fields due to a Uniformly Moving charge and An Accelerated Charge, Linear and Circular Acceleration and Angular Distribution of Power Radiated, Bremsstrahlung, Synchrotron Radiation and Cerenkov Radiation, Reaction Force of Radiation, Electromagnetic Mass of the Electron.

Dynamics of Charged Particles in E and B Fields:
Motion of Charged Particles in electromagnetic Field: Uniform E and B Fields, Non-uniform Fields Diffusion Across Magnetic Fields, Time Varying E and B Fields.

Plasma Physics:
Elementary Concepts: Plasma Oscillations, Debye Shielding, Plasma Parameters, Magnetoplasma, Plasma Confinement, Firt, Second, and Third Adiabatic Invariants (Pinch Effect, Magnetic Mirrors), Formation of Van Allen Belt.

Hydrodynamical Description of Plasma:
Fundamental equations, Hydromagnetic Waves: Magnetosonic and Alfven Waves, Magnetoconvection and Sun Spots, Bipolar magnetic Regions and Magnetic Buoyancy, Magnetised Winds (Solar Wind).

Wave Phenomena in Magnetoplasma:
Polarisation, Phase Velocity, Group Velocity, Cut-offs, Resonance for Electromagnetic Wave Propagating Parallel and Perpendicular to the Magnetic Field Propagation at Finite Angle.

Reference Books:

1. Classical Electricity and Magnetism: W.K.H. Panofsky and M. Phillips.
2. Plasma Physics: A Bittencourt.
3. Plasma Physics and Controlled Fusion: F.F. Chen.
4. Classical Electrodynamics: J.D. Jackson.

MPC-202: ATOMIC, MOLECULAR PHYSICS AND LASER **Credits: 3**

Atomic Physics:
Dipole selection rules (examples with derivation), Width and shape of spectral lines, Spin-orbit coupling, Lamb shift and Retherford experiment, Hyperfine structure of lines, Normal and specific mass shifts, excitation and ionization processes in electron-atom collisions, experimental determination of collision cross section, Principle of ESR with experimental setup, chemical shift.

Molecular Physics:
Molecular Orbital and Electronic configuration of Diatomic molecules: H_2, C_2, O_2, NO and CN; Vibrational structure and vibrational analysis, Frank Condon Principle, Dissociation Energy, Rotational Raman spectra and influence of nuclear spin.

Lasers:
Requisites for producing laser light, Role of Plane and Confocal cavity resonators, Longitudinal and transverse cavity modes, Mode selection, Q-switching and Mode locking, Generation of Ultra short Pulses.

Reference Books:

1. Physics of Atoms and Molecules: Bransden and Joachain.
2. Lasers - Theory and Applications: K. Thyagrajan and A.K. Ghatak.
3. Introduction to Atomic Spectra: H.E. White.
4. Introduction to Atomic Spectra: HG Kuhn.

MPC-203: ELEMENTS OF SOLID STATE PHYSICS **Credits: 3**

Structure and Symmetry:
Structural description of liquids and solids (amorphous and crystalline), External symmetry elements and concept of point groups, Direct periodic lattices, Basic concept of aperiodicity, Reciprocal lattice and diffraction conditions and its relation with Brillouin zones, Intensity of Bragg scattering from a unit cell and extinction conditions.

Lattice Vibrations:
Interatomic forces and lattice dynamics of crystals with up to two atoms per primitive basis, Quantization of elastic waves.

Electronic Properties of Solids:
Electrons in periodic potential, Band Theory, Tight Binding, Cellular and Pseudo potential methods, Symmetry of energy bands, density of states, Fermi surface, De Haas von Alfen effect, Elementary ideas of quantum Hall effect, Cyclotron resonance and magnetoresistance,

Introduction to superconductivity.

Reference Books:

1. Introduction of Solids: L.V. Azaroff
2. Crystallography Applied to Solid State Physics: A.R. Verma and O.N. Srivastava
3. Principels of Condensed Matter Physics: P.M. Chaikin and T.C. Lubensky
4. Solid State Physics-Structure and Properties of Materials : M.A. Wahab
5. Solid State Physics: N.W. Ashcroft and N.D. Mermin.

MPC-204: ELEMENTS OF NUCLEAR PHYSICS **Credits: 3**

Detectors and Accelerators:
Outline of interaction of charged particles and of Gamma-rays with matter.
Detectors: Gas Filled counters (ionization Chamber), Scintillation counter, Spark Chambers, Cerenkov detectors.
Accelerators: Ion Sources, Synchrotron, Introduction of Modern Colliders (LHC and RHIC), Storage Ring.

Nuclear Reactions:
Discussion of Direct and Compound nuclear reaction mechanisms, expressions for scattering and reaction cross-sections in terms of partial wave amplitudes, Resonances, Discussions and Applications of Breit-Wigner single-level formula, compound nucleus theory.

Nuclear Decay:
Electromagnetic interactions in nuclei, Multipole transitions in nuclei, Parity and angular momentum selection rules, Internal conversion, Fermi theory of beta-decay, Curie plots, Comparative half life, Allowed and forbidden transitions, Detection and properties of neutrino.

2-Body Problem:
Deuteron problem, Tensor force, S and D states, Neutron-Proton and proton-proton scattering, Effective range theory, Spin-dependence of nuclear forces, Charge independence and charge symmetry of nuclear forces, Isospin formalism.

Particle Physics: Basic interactions in nature, Elementary particles, Quantum numbers and conservation laws, Concept of isospin, Quarks and colors, Quark model, Eightfold way, Mesons and Baryons, Bound states and resonance states.

Reference Books:

1. Atomic and Nuclear Physics Vol. II: Ghoshal.
2. Nuclear Structure: Preston and Bhaduri.
3. Nuclear Structure: Pal.
4. Introductory Nuclear Physics: Wong.
5. Nuclear Theory: Elton.
6. Nuclear Interactions: de Benedetti.

MPME-201: APPLIED RADIATION PHYSICS **Credits: 3**

(

This minor elective is open to M.Sc. students of Physics as well as other Departments)

Basic Nuclear Processes in Radioactive Sources:
Characteristics of nuclear radiations, alpha decay, beta decay, electron capture, gamma emission, annihilation radiation, neutron sources, source activity, radioactivity decay law, decay chains.

Passage of Radiation through Matter:
The cross section, interaction probability in a distance and mean free path, Stopping power of charge particles-Qualitative discussion of the Bethe-Bloch formula, Radiation length, Range of electrons, Interaction of photons, neutrons and charges particles.

Radiation Protection:

Dosimetric Units: The Roentgen, Absorbed dose, Relative Biological effectiveness (RBE), Equivalent dose, Effective Dose, Typical doses from sources (Natural, Environmental & Medical exposures), Radiation shielding and its safety (Gamma-rays, electrons, positrons, charged particles, Neutrons), Ethics of radiations.

Radiation Effects on Biological Systems:
High doses received in a short time, Low-level doses limits, direct ionization of DNA, radiation damage to DNA, Biological effects (Genetic, Somatic, Cancer and sterlity).

General Characteristics of Detectors:
Sensitivity, Detector response, Energy resolution, Response time, Detector efficiency, Dead time, Ionization mechanism and introductory idea about some detectors.

Reference Books:

1. A Primer in Applied Radiation Physics: F.A. Smith.
2. Introduction to Experimental Nuclear Physics: R.M. Singru.
3. Radiation Biophysics: E.L. Alpen.
4. Atom, Radiation and Radiation Protection: J. Turner.

MPL-201: ELECTRONICS LABORATORY **Credits: 4**

Students assigned the electronics laboratory work will perform at least eight (08) experiments of the following:

1. Addition, Subtraction and Binary to BCD conversion
2. JK Flip-Flop and up-down counter
3. Transmission Line Experiment
4. Negative Feedback Experiment
5. Multivibrator
6. Differential Amplifier
7. Op-amps and its application
8. IC 555 Timer
9. Design of CE Amplifier
10. Design of Regulated Power Supply
11. Arithmetic Logic Unit
12. Receiver characteristics

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-202: GENERAL PHYSICS & OPTICS LABORATORY **Credits: 4**

Students assigned the general laboratory work will perform at least eight (08) experiments of the following:

1. Ionization potential of Lithium
2. Zeeman Effect
3. Dissociation Energy of I_2 molecule
4. Hall Effect
5. Four Probe Method
6. Electron Spin Resonance
7. Telexometer
8. Experiment on high intensity monochromator
9. Faraday Effect and Kerr Effect
10. Frank-Hertz experiment
11. Compton Effect
12. Atomic Spectra of two-Electron Systems

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-203: COMPUTATIONAL PHYSICS & PROGRAMMING LABORATORY **Credits: 2**

Students assigned the computer laboratory work will perform in Semester – II at least four (04) experiments (other than what they have done in Semester – I) of the following:

1. Jacobi Method of Matrix Diagonalization
2. Solution of transcendental or polynomial equations by the Newton Raphson method
3. Linear curve fitting and calculation of linear correlation coefficient
4. Matrix summation, subtraction and multiplication
5. Matrix inversion and solution of simultaneous equation
6. Lagrange interpolation based on given input data
7. Numerical integration using the Simpson's method
8. Numerical integrationg using the Gaussian quadrature method
9. Solution of first order differential equations using the Rung-Kutta method
10. Numerical first order differentiation of a given function
11. Fast Fourier Transform
12. Monte Carlo integration
13. Use of a package for data generation and graph plotting.
14. Test of randomness for random numbers generators

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

SEMESTER-III

MPC-301: STATISTICAL MECHANICS – I **Credits: 4**

Review:
Canonical and Grand-Canonical ensembles, Partition function, Thermodynamic Functions, Bose Condensation, Correlation in a Fermi gas.

Quantum Statistical Mechanics:
Density matrices, Density matrix in statistical mechanics, Linear Harmonic and anharmonic oscillators, Wigner's function, Perturbation expansion of the density matrix.

Statistical Mechanics of Interacting Systems:
Cluster expansion for a classical gas, Mayer cluster expansion, Equation of state, Radial distribution function, thermodynamic functions in terms of Radial distribution functions.
Quantum cluster expansion, exact treatment of second virial coefficient. Weakly interacting Bose gas, excitation spectrum, super-fluidity in liquid He II, Low temperature behaviour of Bose and Fermi gases, Ising model, mean-field theory in zeroth and first approximations, exact solution in one dimension.

Reference Books:
1. Statistical Mechanics: Parharia.
2. Statistical Mechanics: Haung.
3. Statistical Mechanics: Ma.
4. Statistical Mechanics: Landau and Lifshitz.

MPC-302: QUANTUM MECHANICS – II **Credits: 3**

Identical Particles:
Permutation symmetry, symmetrization postulates, self consistent field approximation, Slater determinant, Hartree Fock method.

Relativistic Quantum Mechanics:
Klein Gordon equation, Dirac equation, negative energy solutions, antiparticles, Dirac hole theory, Feynman interpretation of antiparticles, Gama-matrics and their properties, Convariance of Dirac equation, Charge conjugation, Parity & Time reversal invariance, Bilinear covariants, Plane wave solution, Two component theory of neutrino, Spin & Helicity, Relativistic Hydrogen atom problem.

Field Quantization:
Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether's theorem, cononical quantization of scalar field, Complex scalar field, electromagnetic field and Dirac field, Problem in quanitizing electromagnetic field, Gupta & Bleuler method, Feynman rules (without derivation), Feynman diagrams.

Reference Books:

1. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
2. Relativistic Quantum Fields: J.D. Bjorken and S.D. Drell.
3. A First Book on Quantum Field Theory: Amitabha Lahiri and P.B. Pal.
4. Introduction to QFT: F. Mandle and G. Shaw.
5. Modern Quantum Mechanics: J.J.Sakurai.
6. Principles of Quantum Mechanic: R. Shankar.

MPS-301 (A): ANALOG COMMUNICATION SYSTEMS **Credits: 4**

Microwave Electronics:
Microwave characteristic features & Application, Waveguides and Cavity Resonators, Two cavities Klystron, Reflex Klystron, Semiconductor Gunn diode characteristics. Microwave antenna, Detection of microwave, Dielectric constant measurement, Isolator and circulator, PIN diode modulator, Directional coupler.

Radar Communication:
Basic Radar systems, Radar range equation and performance factor, Radar Cross-section, Pulsed Radar system, Duplexer, Radar Display, Doppler Radar, CWIF Radar, FMCW Radar, Moving Target Indicator (MTI), Blind Speeds.

Analog Signal Transmission:
Introduction, Amplitude, Frequency & phase modulation, AM, FM, Modulating and Demodulating circuits, AM, FM Receivers functioning (BLOCK diagram) and Characteristic Features, Pulse modulation, Sampling processes, PAM, PWM and PPM modulation and demodulation, Quantization processes, Companding and Quantization noise, PCM, Differential PCM and Delta Modulation systems, Comparison of PCM and DM, Time division multiplexing.

Satellite Communication:
Principle of Satellite Communication, Satellite frequency allocation and band spectrum, Satellite orbit, trajectory and its stability, Satellite link design, Elements of Digital Satellite Communication, Multiple Access technique, Antenna system, Transponder, Satellite Applications.

Reference Books:

1. Communication System: Simon Haykin.
2. Electronics communication: Roddy and Coolen.
3. Microwave and Radar Engineering: M. Kulkarni.
4. Digital and analog communication systems : K.San Shanmugam.
5. Satellite Communication: Pratt and Bostiern.
6. Microwave: K.C. Gupta

MPS-301(B): NUCLEAR PHYSICS: INTERACTIONS AND MODELS **Credits: 4**

N-N interaction:
Phenomenological N-N Potentials (Soft core & hard core) and meson theoretical potentials, Polarization in N-N scattering.
Probing charge distribution with electrons, Form factors, Proton form factors, Qualitative ideas on deep inelastic electron-proton scattering, Bjorken scaling and the parton model, Quark structure of the nucleon.

Nuclear Models:
Single particle model of the nucleus, Angular momenta and parities of nuclear ground states, Qualitative discussion and estimates of transition rates, Magnetic moments and Schmidt lines.

Classification of shells, Seniority, Configuration mixing, Pairing Force theory, Simple description of Two-particle shell model spectroscopy.
Deformable liquid drop and nuclear fission, Collective vibrations and excited states, Permanent deformation and collective rotations: Energy levels and electromagnetic properties of even-even and odd-A deformed nuclei, Nilsson model and equilibrium deformation, Coulomb Excitation Studies, Behaviour of Nuclei at high spin, Back-bending.

Reference Books:

1. Atomic and Nuclear Physics Vol. II: Ghoshal.
2. Nuclear Structure: Preston and Bhaduri.
3. Nucleon-nucleon Interaction: Brown and Jackson.
4. Introductory Nuclear Physics: S.S.M. Wong.
5. Nuclear Structure: M.K.Pal.

Credits: 4

MPS-301(C): VIBRATIONAL AND ROTATIONAL MOLECULAR SPECTROSCOPY

Symmetry and Group Theoretical Treatment:
Molecular symmetry and Group Theory, Matrix Representations of symmetry elements of a Point Group. Reducible and irreducible Representations, Character Tables for C_{2v} and C_{3v} point groups. Normal modes of vibration and their distribution into symmetry species of the molecule, Infrared and Raman Selection rules, Overtone and Combination Bands, Vibrational Potentials with more than one minimum. Qualitative treatment of inversion vibrations and Torsional vibrations.

Vibration-Rotation Energy Levels and Spectra:
Rotational Energy of Spherical, Prolate and Oblate Symmetric Rotors, Rotational Raman and IR Spectra of linear molecules and Determination of their Geometry. Rotation-Vibration Band of a Diatomic Molecule, Parallel and Perpendicular type Bands in Linear and symmetric Rotor Molecules. Qualitative description of Type A, B and C bands in Asymmetric Rotor Molecules.

Reference Books:

1. Chemical Applications of Group Theory : F.A. Cotton.
2. Fundamentals of Molecular Spectroscopy : C.N. Banwell.
3. Introduction to Molecular Spectroscopy : G.M. Barrow.
4. Modern Spectroscopy : J.M. Hollas.

MPS – 301(D): SOLID STATE PHYSICS: CRYSTALLOGRAPHY AND IMPERFECTION IN CRYSTALS **Credits: 4**

Crystallography:
Elementary concepts of space group and its relevance to crystal structure. Principle of Powder diffractometer, Interpretation of powder photographs, Analytical indexing: Ito's methods. Accurate determination of lattice parameters – least-square method. Retvil analysis, Application of powder method.
Interpretation of oscillation photograph, X-ray method of orienting crystals about a crystallographic direction, Bernal chart, Indexing of reflections, Buerger's precession method.
Determination of relative structure amplitudes from measured intensity (Lorentz and Polarization factors), Fourier representation of electron density, The phase problem, Patterson function.

Imperfection of Crystals:
Mechanism of plastic deformation in solids, Stress and strain fields of screw and edge dislocations, Elastic energy of dislocations, Forces between dislocations, Stress needed to operate Frank-Read source, Dislocations in fcc, hcp and bcc lattices, Partial dislocations and stacking faults in close-packed structures.
Experimental method of detecting dislocations and stacking faults, Electron Microscopy: Kinematical theory of diffraction contrast and lattice imaging.

Reference Books:

1. Crystallography for Solid State Physics: Verma and Srivastava.
2. X-ray Crystallography: Azarof.

3. Elementary Dislocation Theory: Weertman and Weertman.
4. Crystal Structure Analysis: Buerge.
5. Electron Microscopy of Thin Crystals: Hirsh.

MPME-301: EXPERIMENTAL TECHNIQUES FOR ANALYTICAL STUDIES Credits: 3

(This minor elective is open to M.Sc. students of Physics as well as other Departments)

Spectroscopic Techniques:
Dispersing devices and detectors: Dispersion and resolution of a prism and a grating spectrometer, Single and double monochromators, Photomultiplier tube, Charge coupled detectors (CCD).

UV and Visible absorption spectroscopy, IR and Raman spectroscopy: Identification of groups, hydrogen bonding and study of conformers, Time–resolved spectroscopy and study of biological samples.

Qualitative and quantitative analysis of trace elements.

Basics of nuclear magnetic resonance (NMR) and electron spin resonance (ESR) spectroscopy, Mössbauer spectroscopy, Microwave spectroscopy, Photoacoustic spectroscopy and their applications.

Laser as a source of radiation and its characteristics, Laser fluorescence and absorption spectroscopy, Multi-photon ionization and separation of isotopes.

Structural Characterization Techniques:
Microstructural characterization, Basics and applications of Scanning electron microscopy (SEM), Biological applications of scanning probe microscopy, Confocal microscopy, Focussed ion beam system.

Reference Books:
1. Spectroscopy Volume 1, 2 and 3: B.P. Straughan and S. Walker.
2. Modern Spectroscopy: J.M. Hollas.
3. Transmission Electron Microscopy of Metals: Gareth Thomas
4. Elements of X-ray Diffraction: Bernard Dennis Cullity.
5. Atomic Force Microscopy/Scanning Tunneling Microscopy: M.T. Bray, Samuel H. Cohen and Marcia L. Lightbody.

MPE-301: PLASMA AND SPACE PHYSICS **Credits: 3**

Plasma Physics:
Trapped Particle Motion:
Collisions, Conductivity, Diffusion along and across magnetic field, convection electric field, Ring current.

Multifluid Theory:
Equation of state, Frozen in Field concept, Stationarity & Equilibria, MHD waves in Dipolar Magnetic Field, Sources of wave energy and instabilities.

Kinetic theory of Plasma:
Boltzmann-Vlasov Equation, Transport Equation, Landau Damping, Collision Damping, Wave Amplification, Role of magnetic field, Wave in Planetary Magnetosphere.

Space Physics:

Solar Phenomena:

Structure of the Sun, Solar Activity, Prominences, Coronal Heating, Solar Flares.

Solar Wind:
Properties, solar wind formations, Interaction of Solar Wind with Magnetized and Unmagnetized Planets.

Magnetophere:
Magnetopause, Magnetotail, Magnetic reconnection, Magnetosphere, Plasma flow in the magnetosphere.

Ionosphere:
Structure, Ionospheric Irregularities, Aurora, Borealis, Magnetosphere- Ionosphere coupling.

Reference Books:

1. Basic Space Plasma Physics: W. Baumjohau and R. A. Treumann.
2. Introduction to Space Physics: Edited by M. G. Kevilson and C. T. Russell.
3. Space Plasma Physics: A.C. Das.
4. Plasma Physics and Introductory Courses: Edited by Rechered Dendy.
5. Introduction of Plasma Physics: R.J. Goldston and P.H. Rutherford.

MPE-302: LASERS AND LASER APPLICATIONS **Credits: 3**

Basic Principle and Different Lasers:
Principle and Working of CO_2 laser and Qualitative Description of Longitudinal and TE laser systems. Threshold condition for Oscillation in Semiconductor Laser. Homostructure and Heterostructure p–n junction lasers, Nd-YAG lasers. Principle of Excimer Laser. Principle and Working of Dye Laser. Free Electron Laser.

Non Linear Processes:
Propagation of Electromagnetic Waves in Nonlinear medium, Self Focusing, Phase matching condition, Fiber Lasers, Stimulated Raman Scattering and Raman Lasers, CARS, Saturation and Two photon Absorptions.

Novel Applications of Laser:
Cooling and Trapping of Atoms, Principles of Doppler and Polarization Gradient Cooling, Qualitative Description of Ion Traps, Optical Traps and Magneto-Optical Traps, Evaporative Cooling and Bose Condensation.

Reference Books:

1. Laser Spectroscopy and Instrumentation : W. Demtroder.
2. Principles of Lasers : O. Svelto.
3. Laser Cooling and Trapping : P.N. Ghosh.
4. Frontiers in Atomic, Molecular and Optical Physics : S.P. Sengupta.

MPE-303: CHARACTERIZATION OF SOLIDS **Credits: 3**

Structural Characterization:
Intense X-ray Sources : Synchrotron Radiation, General theory of X-ray scattering and diffraction, Reciprocal space of perfect and imperfect crystals, X-ray diffraction characterization of imperfections in crystals, Basic concepts of small angle X-ray scattering and its application in evaluation of shape and size of surface particles. Neutron scattering and diffraction with reference to light elements and magnetic structures.

Electronic Characterization:
LEED (Low Energy Electron Diffraction) for Surface Structure, Surface Topography, Elementary Concepts of Scanning and Scanning Tunneling Microscopic Techniques (SEM, STM) X-ray Photoelectron Spectroscopy (XPS/ESCA) for chemical analysis. Methods.RBS (Rutherford Back Scattering) and SIMS (Secondary Ion Mass Spectroscopy). Defect related electronic states characterization by C-V characteristics of electronic junction devices, Temperature stimulated current and capacitance (TSC/TSCAP), Deep Level Transient Spectroscopy (DLTS), Electronic Beam Induced Current (EBIC) and Light Beam Induced Current (LBIC).

Spectroscopic Characterization:
Double Beam IR Spectrometers, Basic Concepts of Raman Spectroscopy in Solids, Sensitive Detectors such as CCD Camera, Concept of Space Group and Point Group, Identification and Analysis of Optic and Acoustic Modes in Solids. Electronic Absorption Study for Band Gap Determination.

Reference Books:

1. Analytical Techniques for Thin Film - Treatise on Material Science and Technology, Vol. 27: K.N. Tu and R. Rosenberg (ed.).
2. Electron Microprobe Analysis: S.J. B. Reed.
3. Topics in Applied Physics, Vol. 4: R. Gomer (ed.).
4. Analysis of High Temperature Materials: O. Van Der Biest (ed.).

MPE-304: MOLECULAR BIOPHYSICS **Credits: 3**

Basic Concepts in Biophysics:

Elementary ideas about the DNA structure, sugar-phosphate backbone, nucleosides and nucleotides, three-dimensional DNA structure, RNA. Proteins: primary, secondary, tertiary and quaternary structures, enzymes and their catalytic activity, DNA and protein folding, DNA denaturation, replication, mutation, intercalation, neurotransmitters, membranes.

DNA and its Role:

Forces stabilizing DNA and protein structure, Theoretical quantum chemical and molecular mechanical methods, Treatment of intermolecular interactions, conformations, hydrogen bonding, stacking and hydrophobic interactions, importance of electrostatic interactions, biomolecular recognition, drug design.

Experimental Techniques:

Application of experimental techniques of light scattering, absorption and fluorescence spectroscopy, Nuclear magnetic resonance, Interaction of UV radiation with DNA, Photodimerization, Photodynamic action.

Reference Books:

1. Essentials of Biophysics: P. Narayanan.
2. Basic Molecular Biology: Price.
3. Quantum Mechanics of Molecular Conformations: Pullman (Ed.).
4. Non-linear Physics of DNA: Yakushevich.
5. Biological Physics: Nelson.

MPE-305: METHODS IN THEORETICAL PHYSICS **Credits: 3**

Path-integral Formalism:
Path-integral formalism in Quantum mechanics, applications to free particle and linear harmonic oscillator; Connection with statistical mechanics.

Foundations in Quantum Mechanics:
Statistical interpretation of Schrodinger's wave functions, Hidden variable and Copenhagen interpretation; EPR paradox and Bell's theorem; Geometrical phase and Aharanov-Bohm effect; Quantum measurement, No-clone theorem, schrodinger's Cat and Quantum Zeno paradox.

General theory of Relativity and Cosmology:
Tensors, metrics and geodesics, dyadics, covariant and contravariant derivatives, Christoffel's symbol and Levi-civita symbol; Einstein's equation and Schwarzchild's solution; Applications in cosmology, Black-holes.

Constraints and Gauge Theory:
Hamilton Method, Constraints (first class and second class); Gauge theory, gauge invariance and related physics.

Reference Books:

1. Techniques and Applications of Path Integration: L.S. Schulman.
2. Introduction to Quantum Mechanics: D.J. Griffiths.
3. Gravitation and Cosmology: S. Weinberg.
4. Classical Dynamics: E.C.G. Sudarshan and N. Mukunda.
5. Lectures on Quantum Mechanics: P.A.M. Dirac.

MPE-306: INSTRUMENTATION IN NUCLEAR AND PARTICLE PHYSICS Credits: 3

Standard Radioactive Sources:
Units, Fast Electron, Heavy Charged Particle, Radiation, Neutron Sources, Biological effects of Radiation, Quantification of Dose Type of Exposure, maximum permissible dose rate.

General Properties of Radiation Detectors:

Simplified detector model, Current and pulse modes of operation, pulse heigh spectra, counting curves and plateaus, energy resolution, detection efficiency, dead time. Device impedances, coaxial cables, Pulse shaping. General characteristics of single & multi-channel methods, spectrum stabilization and computerized spectrum analysis.

Linear and Logic Pulse Functions:
Fast and slow pulses, Linear and logic pulses, instrument standards, Function of pulse processing units, components common to many applications, pulse counting systems, pulse height analysis systems, systems involving pulse timing and pulse shape discrimination.

Background and Detector Shielding:
Sources of background, Background in Gamma ray spectra, Active methods of background reduction, shielding consideration against radiation from an accelerator and radioactive sources.

Counting Statistics and Error Estimation:
Characterization of data, statistical models and applications, error propagation, optimization of counting experiments, and distribution of time intervals.

Reference Books:
1. Radiation Detection and Measurement: G.F. Knoll.
2. Nuclear Physics Techniques: W.R. Leo.
3. Introduction to Nuclear and Particle Physics(2^{nd} Edition): A Das and T. Ferbel.

MPE-307: SCIENCE AND TECHNOLOGY OF SOLAR ENERGY, HYDROGEN AND OTHER RENEWABLE ENERGIES **Credits: 3**

Solar Energy: Fundamental and Material Aspects:
Fundamentals of photovoltaic Energy Conversion Physics and Material Properties, Basic to Photovoltaic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.

Solar Energy: Different Types of Solar Cells:
Types of Solar Cells, p-n junction solar cell, Transport Equation, Current Density, Open circuit voltage and short circuit current, Brief description of single crystal silicon and organic and Polymer Solar Cells, Elementary Ideas of Advanced Solar Cells e.g. Tandem Solar cells, Solid Liquid Junction Solar Cells, Nature of Semiconductor, Principles of Photo-electrochemical Solar Cells.

Hydrogen Energy: Fundamentals, Production and Storage:
Relevance in relation to depletion of fossil fuels and environmental considerations. Solar Hydrogen through Photoelectrolysis, Physics of material characteristics for production of Solar Hydrogen. Brief discussion of various storage processes, special features of solid hydrogen storage materials, Structural and electronic characteristics of storage materials. New Storage Modes.

Hydrogen Energy: Safety and Utilization:
Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Various type of Fuel Cells, Applications of Fuel Cell, Elementary concepts of other Hydrogen- Based devices such as Hydride Batteries.

Reference Books:
1. Solar Cell Devices-Physics :Fonash
2. Fundamentals of Solar Cells Photovoltaic Solar Energy :Fahrenbruch & Bube
3. Phoptoelectrochemical Solar Cells: Chandra
4. Hydrogen as an Energy Carrier Technologies Systems Economy : Winter & Nitch (Eds.)
5. Hydrogen as a Future Engery Carrier : Andreas Zuttel, Andreas Borgschulte and Louis Schlapbach

MPL-301(A): Electronics Laboratory **Credits: 6**

Students will be required to perform six (06) experiments of the following:

1. Microwave characteristics and measurements

2. Nonlinear applications of Op amplifier
3. PLL characteristics and its applications
4. PAM, PWM and PPM Modulation and demodulation.
5. PCM / delta modulation and demodulation
6. Fiber optic communication
7. Experiments on MUX, DEMUX, Decoder and shift register
8. Arithmetic operations using microprocessors 8085 / 8086
9. D/A converter interfacing and frequency / temperature measurement with microprocessor 8085 / 8086
10. A/D converter interfacing and AC/DC voltage / current measurement using microprocessor 8085/8086
11. PPI 8251 interfacing with microprocessor for serial communication.
12. Assembly language program on P.C

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(B): Nuclear Physics Laboratory ***Credits: 6***

Students will be required to perform seven (07) experiments of the following:

1. Gamma - Ray Spectroscopy Using NaI (Tl) detector
2. Alpha Sepctroscopy with Surface Barrier Detector
3. Determination of the range and energy of alpha particles using spark counter
4. Study of gamma ray absorption process
5. X-Ray Fluorescence
6. Neutron Activation Analysis Measurement of the Thermal Neutron Flux
7. To Study the Solid State Nuclear Track Detector
8. Fission Fragment Energy Loss Measurements from Cf^{252}
9. Gamma - Gamma Coicidence studies
10. Compton Scattering: Energy Determination
11. Compton Scattering: Cross-Section Determination
12. Determination of energy of mu-mesons in pi-decay using Nuclear Emulsion Technique
13. Identification of particles by visual range in Nuclear Emulsion
14. Study of Rutherford Scattering

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(C): SPECTROSCOPY LABORATORY ***Credits: 6***

Students will be required to perform six (06) experiments of the following:

1. Verification of Hartmann formula for prism spectrogram
2. Measurement of optical spectrum of an alkali atom
3. Determination of metallic component of an inorganic salt
4. Emitter of electric discharge through air in a tube with minute leak
5. Emitter of electric discharge through air in an evacuated tube
6. Measurement of optical spectrum of alkaline earth atoms
7. Measurement of Band positions and determination of vibrational constants of AlO molecule
8. Measurement of Band positions and determination of vibrational constants of N_2 molecule
9. Measurement of Band positions and determination of vibrational constants of CN molecule
10. Measurement and analysis of fluorescence spectrum of I_2 vapour
11. Determination of characteristic parameters of an optical fiber
12. Measurement of Raman spectrum of CCl_4.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(D): SOLID STATE PHYSICS LABORATORY **Credits: 6**

Students will be required to perform five (05) experiments of the following:

1. Measurement of lattice parameter and indexing of powder photograph
2. Identification of unknown sample using powder diffraction method.
3. To study the ferroelectric transition in TGS crystal and measurement of Curie temperature
4. To measure the superconductivity transition temperature and transition width of a high temperature superconductor
5. Rotation / oscillation photograph and their interpretation
6. To study the modulus of rigidity and internal friction in a metal as a functioning temperature
7. To measure the Cleavage step height of a crystal by multiple Fizeau Fringes
8. To determine magnetoresistance of a Bismrith crystal as a function of magnetic field
9. Synthesis/Fabrication of Cabon Nanotubes by Spray Pysolysis method and its verification through x-ray diffraction.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

SEMESTER – IV

MPC-401: STATISTICAL MECHANICS – II **Credits: 3**

Critical Phenomena and Phase Transition**:**
Phase transitions and thermodynamic functions. Thermodynamic limit and its importance. Mean field theory, Landau theory. Correlation functions, Ornstein-Zernike theory, Critical behaviour, Critical exponents, Scaling and Universality, Upper and lower critical dimensions. Renormalization group: basic idea, flows, fixed points, Application to 2-d Ising and Potts models.

Time Dependent Phenomena:

Dynamic correlation and response functions. Example of damped harmonic oscillator. Diffusion. Brownian motion and Langevin equations.Correlation and response of damped Brownian oscillator. General properties of correlation and response functions, Linear response theory. Dissipation: The fluctuation-dissipation theorem, The Kubo formula, Fokker-Planck Equation.

Reference Books:

1. Statistical Mechanics: Patheria.
2. Statistical Physics I and II: Kubo, Toda and Ashitsume.
3. Modern Theory of Critical Phenomena: Ma.
4. Statistical Mechanics: Landau and Lifshitz.
5. Lectures on Phase Transitions and Rnormalization Group: Goldenfeild.

MPS-401(A): DIGITAL COMMUNICATION SYSTEMS **Credits: 4**

Signals, Systems and Noise:
Elements of communication systems, Fourier representation of periodic and non-periodic signals, Power spectral density, Impulse and step response of systems, Time and frequency domain analysis of systems, Ideal and Real filters, Noise in communication systems, Representation of narrow band noise, Signal to noise ratio, Noise equivalent band width and noise figure.

Information Theory and Coding:
Introduction, Amount of information, Average information, Shannon's encoding algorithm, Communication channels, Rate of information and capacity of discrete memoryless channels, Shanon-Hartley theorem. Linear block codes, Binary cyclic codes and Convolutions codes.

Digital Signal (Data) Transmission:

Introducation, Base band and pass band data transmission. Base band binary PAM system, Optimum receiver for binary digital modulation schemes, Binary ASK, FSK PSK and differential PSK signaling schemes. Brief idea about M-ary signaling schemes, Serial data communication in computers, USART 8251, MODEM.

Fiber Optic Communication:
Basic optical communication system, wave propagation in optical fiber media, step and graded index fiber, material dispersion and mode propagation, losses in fiber, optical fiber source and detector, optical joints and coupler. Digital optical fiber communication system, First/Second generation system, Data communication network.

Reference Books:

1. Digital and Analog Communication Systems: K. San Shanmugam.
2. Communication Systems: Simon Haykin.
3. Optical Fibre Communication: Kaiser.

MPS-401(B): PARTICLE PHYSICS **Credits: 4**

Particle Phenomenology:
Invariance and conservation laws in relation to particle reactions and decays. Elementary ideas of C, P and T symmetries. Pion-nucleon scattering, isospin analysis and phase shifts, resonances and their quantum numbers, Production and formation experiments, Relativistic kinematics & invariants, Mandelstam variables, Phase space, Decay of one particle into three particles, Dalitz Plot.

Strong Interactions and Symmetries:
Uses of symmetry, space time and internal symmetries, Lie groups generators and Lie algebra, Casimir operators, SU(2) irreducible representation, weight diagram, diagonal generators, SU(3) generators, U and V spin, Raising and Lowering operators, Root diagram, Weight diagram, Dimensionality multiplets of SU(n), Baryons and meson multiplets, Symmetry breaking and Gell-Mann-Okubo mass formula, Decays in terms of Quark Model.

Physics of Quarks and Gluons:
Charm, bottom and top quarks and higher symmetry. Quark-Gluon interaction, Experimental tests of Quantum Chromodynamics. Particle Physics and Thermodynamics in the early Universe. Quark-Gluon Plasma. Stellar evolution and Element Synthesis.

Reference Books:

1. Nuclear and Particle Physics: W. Burcham and M. Jobes.
2. Quarks and Leptons: Halzen and Martin.
3. Unitary symmetry and Elementary Particles: D.B.Lichtenberg.
4. Symmetry Principles in particle Physics: Emmerson.
5. Introduction to High Energy Physics: Perkins.
6. Particles and Nuclei: B. Povh, K. Rith, C. Scholz and F. Zetsche.

MPS-401(C): MOLECULAR ORBITAL THEORY AND ELECTRONIC SPECTRA OF MOLECULES **Credits: 4**

Atomic and Molecular Orbital Theories:
Elementary idea of Atomic Orbitals in Hartree-Fock Theory, Qualitative description of ab-initio methods, LCAO treatment of H_2^+ and H_2 molecules. Molecular charge distribution and Dipole moment. Molecular Electrostatic Potential. Hellman-Feynman Theorem and concept of force. Hybrid Atomic Orbitals in H_2O, CH_4, C_2H_2, and C_2H_4. Concept of lone pairs. Huckel method and its application to Ethylene, Butadiene and Benzene. Changes in molecular geometry on electronic excitation.

Spectroscopy of Diatomic and Poluatomic Molecules:
Coupling of Electrtonic and Rotational motion in Diatomioc Molecules and Rotational structure of $^1\pi$ - $^1\Sigma$ and $^1\Sigma$-$^1\Sigma$ transitions. Vibronic interaction and Herzberg Teller theory for absorption spectrum of benzene vapour.

Single vibronic level spectroscopy and lifetime of vibronic levels in benzene, Quantum yield, Kasha Rule and the concept of nonradiative transitions in molecules. Jablanski diagram and qualitative treatment of small molecule and large molecule limit for nonradiative transitions.

Reference Books:

1. Molecular Orbital Theory: A. Streitweiser.
2. Valence : C.A. Coulson.
3. High Resolution Spectroscopy: J.M. Hollas
4. Laser Spectroscopy and Instrumentation: W. Demtroder.

MPS – 401(D): SOLID STATE PHYSICS: SPECIAL SOLIDS, SURFACES AND PROPERTIES Credits: 4

Aperiodic and Semiperiodic Systems:
Structure and symmetries of liquids, Liquid crystals and amorphous solids. Aperiodic solids and quasicrystals; Fibonaccy sequence, Penrose lattices and their extension to 3-dimensions.

Films and Surface:
Electrical conductivity of thin films, Difference of behaviour of thin films from bulk, Boltzmann Transport equation for a thin film (for diffused scattering), Expression for electrical conductivity.
Elementary concepts of surface crystallography, scanning tunneling and atomic force microcopy.

Magnetic Properties:
Weiss theory of ferromagnetism, Heisenberg model and molecular field theory, Spin waves and magnons, Curie-Weiss law for susceptibility, Ferri and antiferro-magnetic order, Domains and Bloch-wall energy.

Photonic Solids: Fabrication and properties.

Reference Books:

1. Solid State Physics: Kittel.
2. Thin Films: Heavens.
3. Physics of Thin Films: Chopra.
4. Solid State Physics : N.W. Aschroft and N.D. Mermiu

MPS -402(A): MICROPROCESSORS AND INTERFACING **Credits: 4**

Intel 8085:
Internal operation of Intel 8085. Instructions, Opcodes, operands and mnemonics. Constructing machine language codes for instructions, Instruction execution timing diagram. Instruction word size and addressing modes, Instruction set. Stacks subroutines and Interrupts, Machine and assembly language programming.

Intel 8086:
Architecture, Pin description for minimum and maximum modes, Internal operation, Instruction execution timing diagram, Addressing modes. Instruction format for constructing machine language codes for different instructions. Introduction to assembly language. Instruction set and directives, Stacks, Procedures, Macros and interrupts. Flow chart of standard programming structures. I/O interfacing and data transfer scheme.

Advanced Microprosessors:
Multitasking, Architecture and memory management of microprocessor 80286, Brief idea about architecture of microprocessor 80386, 80486 and Pentium, Introduction to Microcontroller.

Microprocessor based Measurement/Control Circuits:
Transducers, D/A and A/D Converters, PPI 8255 Data acquisition and storage, Microprocessor based traffic light controller, Temperature and water label indicator/ controller. DC and steper motor speed measurements, Waveform generation and frequency measurement.

Reference Books:

1. Fundamentals of Microprocessors and Microcomputers: B. Ram.
2. Microprocessor System the 8086 /8088 Family: Liu and Gibson.
3. Microprocessor, Architecture, Programming and Application: R.S. Goonkar.
4. Introduction to Microprocessor: A.P. Mathur.
5. Microprosessor and Interfacing: D.V. Hall.

MPS-402(B): WEAK INTERACTIONS AND ELECTROWEAK UNIFICATION Credits: 4

Weak Interactions:
Leptonic, semileptonic and nonleptonic weak decays. Selection rules, Nuclear Beta decay and form of current-current interaction, Feynman Diagrams, V-A theory, Fermi and G-T selection rules, Parity violation in weak interaction, (Cobalt Sixty Experiment) Neutrino Oscillation and Mixing, Detection of Neutrinos, Decay of Pions and Muons, Calculation of Lifetime for Pions and Muons, Universal Fermi Interaction, Strangeness Oscillations, Regeneration and CP-Violation in Kaon Decay.

Unification of Interactions:
General idea of electro-weak unification, Experimental Evidence of Electro-Weak Unification, Non-Abelian Gauge Field Theory, Spontaneous Symmetry Breaking, Higgs Mechanism, Goldstone Theorem, A Brief Review of Salam-Weinberg-Glashow Model.

Reference Books:
1. Nuclear and Particle Physics: W.E. Burcham and M.Jobes.
2. Introduction to Elementary Particles: Griffths.
3. Quarks and Leptons: Halzen and Martin.
4. Gauge Theory of weak Interactions: Greiner and Muller.

MPS-402 (C): PRINCIPLES AND INSTRUMENTATION IN CONVENTIONAL AND LASER SPECTROSCOPY

Credits: 4

Light Sources, Detectors and Spectroscopic Techniques:
Synchrotron Radiation Source, Dye Laser as a versatile spectroscopic light source, Grating spectrographs and spectrometers based on Czerry-Turner and Ebert mountings. Thermal Detector, Photodiode, Photomultiplier Tube, Channel Electron Multiplier, Charge coupled detector. Principle and Working of a Double Beam infrared spectrophotometer, Raman Spectrometer. Principle and Working of Fourier Transform Spectrometers. Photoacoustic Spectroscopy, Matrix Isolation Spectroscopy.

Non-Conventional Spectroscopic Techniques:
Two-photon spectroscopy, Saturation Spectroscopy, CARS, Experimental techniques of MPI spectroscopy, Optogalvanic spectroscopy and Supersonic Beam Spectroscopy with emphasis on measurement of molecular parameters.

Reference Books:
1. Laser Spectroscopy : W. Demtroder.
2. High Resolution Spectroscopy : J. M. Hollas.
3. Spectrophysics : A. Thorpe.

MPS-402 (D): SOLID STATE PHYSICS: MANY PARTICLE SYSTEMS **Credits: 4**

Interacting Electron Gas:
Hartree and Hartree-Fock Methods, Correlation Energy, Screening, Plasma Oscillations, Dielectric Functions and its Properties, Friedel Oscillations.

Electron-Phonon Interactions:
Interaction of Electron with Acoustic and Optical Phonons, Long Wavelength Limit of Optical Phonons and Crystal Polarization, Polarons, Cooper Pairing due to Phonon, BCS Theory of Superconductivity, Ginzberg-Landau Theory of Superconductivity and Application to type II superconductors, Vortices and Abrikosov Phase.

Optical Properties:
Interactions of Electrons and Phonons with Photons, Direct and Indirect Transitions, Polaritons.

Electron Localiztion in Disordered System:
Electron Localization, Density of States, Mobility Edge, Anderson Model and Mott's Localization, Hopping Conductivity.

Reference Books:

1. Introduction to Solid State Physics: Madelung.
2. Quantum Theory of Solid State: Callaway.
3. Quantum Theory of Solid State: Kittel.

MPE-401: EXPERIMENTAL TECHNIQUES AND INSTRUMENTATION IN ATOMIC, MOLECULAR AND OPTICAL PHYSICS **Credits: 3**

Experimental Techniques:

AES (Auger electron spectroscopy), PES (Photo electron spectroscopy), EELS (Electron energy loss spectroscopy), PIXE (Particle induced x-ray emission), BFS (Beam-foil spectroscopy), TOF (Time-of-flight) spectroscopy, SRS (Synchrootron radiation spectroscopy), technique of coincidence detection, High vacuum generation, Ultra-fast pulse generation and detection.

Instrumentation:

Principle and working of CEM (Channel electron multiplier), MCP (one-and two-dimensional micro-channel plates), PMT (Photo-multiplier tubes), SBD (Surface barrier detectors), Si(Li), HPGe, NaI photon detectors, electrostatic and magnetic charged particle energy analyzers (45^{o}-parallel plate, and cylindrical mirror analyzer (CMA), TOF-spectrometer, MCA (multi-channel analyzer), TAC (Time-to amplitude converter), CFD (Constant fraction discriminator), ionization pressure gauges (Pirani and Penning).

Reference Books:

1. Electron Spectroscopy: Theory, Techniques and Applications: CR Brundle and AD Baker.
2. Synchrotron Radiation : Techniques and Applications: C. Kunz.
3. Low Energy Electron Spectroscopy: KD Sevier.
4. Radiation Detectors: WH Tait.
5. Advances in Image Pickup and Display, Vol. 1: P. Schagen.

MPE-402: NANO SCIENCE AND TECHNOLOGY **Credits: 3**

Nanoparticles: Synthesis and Properties:

Method of Synthesis: RF Plasma Chemical Methods, Thermolysis, Pulsed Laser Methods, Biological Methods: Synthesis using micro-organisms, Synthesis using Plant Extract, Metal Nanoclusters, Magic Numbers, Modeling of Nanoparticles, Bulk to Nano Transitions.

Carbon Nanostructures:

Nature of Carbon Clusters, Discovery of C_{60}, Structure of C_{60} and its Crystal, Superconductivity in C_{60}, Carbon Nanotubes: Synthesis, Structure, Electrical and Mechanical Properties. Graphene: Discovery, Synthesis and Structural Characterization through TEM, Elementary Concept of its applications.

Quantum Wells, Wires and Dots:

Preparation of Quantum Nanostructures, Size Effects, Conduction Electrons and Dimensionality, Properties Dependent on Density of States.

Analysis Techniques for Nano Structures/ Particles:

Scanning Probe Microscopes (SPM), Diffraction Techniques, Spectroscopic Techniques, Magnetic Measurements

Bulk Nanostructure Materials:

Methods of Synthesis, Solid Disorders Nanostructures, Mechanical Properties, Nanostructure Multilayers, Metal Nanocluster, Composite Glasses, Porous Silicon.

Reference Books:

1. Introduction to Nanotechnology: Poole and Owners
2. Quantum Dots : Jacak, Hawrylak and Wojs
3. Handbook of Nanostructured Materials and Nanotechnology : Nalva (editor)
4. Nano Technology/ Principles and Practices**:** S.K. Kulkarni
5. Carbon Nanotubes: Silvana Fiorito
6. Nanotechlongy: Richard Booker and Earl Boysen

MPE-403: PHYSICS OF ELECTRONIC MATERIALS AND DEVICES **Credits: 3**

Physical Mechanisms:
Crystal structures of Electronic materials (Elemental, III-IV and VI semiconductors), Energy Band consideration in solids in relation to semiconductors, Direct and Indirect bands in semiconductor, Electron/Hole concentration and Fermi energy in intrinsic/Extrinsic semiconductor continuity equation, Carrier mobility in semiconductors, Electron and Hole conductivity in semiconductors, Shallow impurities in semiconductors (Ionization Energies), Deep Impurity states in semiconductors, Carrier Trapping and recombination/generation in semiconductors, Schokley Read theory of recombination, Switching in Electronic Devices.

Devices:

(i) Metal/Semiconductor Junction or (Abrupt P-N Junction), Current-voltage characteristics, C-V measurements, Estimation of Barrier Height and carrier concentration from C-V characteristics, Surface/Interface States, Role of interface States in Junction Diodes.

Field Effect devices, C-V characteristic of MIS diodes (Frequency dependence), Estimation of Interface Trapped charges by capacitance conductance, method CCD (Charge Coupled Devices), MESFET, MOSFET.

(ii) **Microwave Devices:** Tunnel Diode, MIS Tunnel Diode, Degenerate and Non-degenerate semiconductor, MIS Switch Diode, MIM Tunnel diode.
IMPATT Diode.
Characteristics, breakdown Voltage, Avalanche Region and Drift Region, Transferred Electron devices.

(iii) **Photonic Devices:** LED and LASER, Photo detectors, Solar-cells.

Reference Books:

1. Physics of Semiconductor Devices: S.M. Sze.
2. Semiconductor Devices Basic Principles: Jaspreet Singh.
3. Physics and Technology of Semiconductor Devices: A.S. Grove.
4. Metal/Semiconductor Schottky Barrier Junction and their Applications: B.L. Sharma.
5. Metal/Semiconductor Contact: Rhoderick.

MPE-404: SATELLITE COMMUNICATION AND REMOTE SENSING Credits: 3

Principle of Satellite Communication:
General and Technical characteristics, Active and Passive satellites, Modem and Codec.

Communication Satellite Link Design:
General link design equation, Atmospheric and Ionospheric effect on link design, Earth station parameters.

Satellite Analog Communication:
Baseband analog signal, FDM techniques, S/N and C/N ratio in FM in satellite link.

Digital Satellite Transmission:
Advantages, Elements of digital satellite communication, Digital base band signal, Digital modulation Techniques, Digital link Design, TDM, TDMA, some applications of satellite communications.

Concept and Foundations of Remote Sensing:
Electromagnetic Radiation (EMR), interaction of EMR with atmosphere and earth surface, Application area of Remote Sensing.

Characteristics of Remote Sensing Platform & Sensors:
Ground, Air & Space platforms, Return Beam Vidicon, Multi-spectral Scanner, Brief idea of Digital Image Processing.

Microwave Remote Sensing Tools:
Radar Remote Sensing, Microwave Sensing, Lidar (Single and double ended system), (Radar & Lidar): Data Characteristics.

Earth Resource Satellites:
Brief description of Landsat and Indian remote sensing satellites (IRS) Satellites.

Reference Books:

1. Satellite Communication : D.C. Agrawal andA. K. Maini.
2. Satellite Communication: T. Pratt and C. W. Bostiern.
3. Satellite Communication System: M. Richharia.
4. Introduction of Remote Sensing: J.B. Campbell.
5. Manual of Remote Sensing Vol I & II: (Ed. R.N. Colwell).

MPE-405: Quantum Field Theory: Path Integral Approach **Credits: 3**

Path integral quantization and Feynman rules: Scalar and Spinor Fields:
Introduction to Path Integrals, Generating functional for scalar fields, Functional integral, Free particle Green's function, Generating functional for interacting fields: φ^4 theory. Effective action for φ^4 theory. Two point functions, Four point functions, Grassman variable, Fermionic functional integrals and generating functional.

Path Integral Quantization: Gauge Fields:
Propagator and gauge condition in QED. Photon propagator, Propagator for transverse photon. Scattering cross section for some elementary process in QED.

Renormalization:
Divergence in φ^4 theory, Dimensional regularization. Renormalization of φ^4 theory. Divergence in QED. Electron self-energy, Vacuum polarization. WT identities. Anomalous magnetic moment of electron. Renormalization group equations.

Reference Books:

1. An introduction of QFT: M. peskin and D. Schroeder.
2. Quantum Filed Theory: L.H. Ryder.
3. Quantum Field Theory: C. Itzykson and J.B. Zuber.
4. Field Theory: Modern Primer: P. Ramond.
5. Relativistic Quantum Field: J.D. Brojken and S.D. Drell.
6. Introduction to QFT: F. Mandle and G. Shaw.

MPE-406: LIQUID CRYSTALS **Credits: 3**

Introduction:
States of matter, Liquid crystals, Symmetry, structure and order, Mesogenic molecules, Liquid crystals of achiral and chiral molecules, calamitic, disc shape and polymer liquid crystals.

Physical Properties:
Order parameters, measurement by magnetic resonance spectroscopy, Optical anisotropy, refractive index, Dielectric anisotropy, dielectric permittivity, Diamagnetic anisotropy, magnetic susceptibility;, Transport properties, Elastic constants, continuum description.

Statistical Theories of Nematic Order:
Landau-de-Gennes theory, hard particle, Maier saupe- and van der Walls type theories.

Nematic-Smectic A transition:
Phenomenological description, McMillan theory, polymorphism in smectic A Phase.

Chiral liquid crystals:
Chirality in liquid crystals: chiral nematic phase, optical properties, field induced nematic-cholesteric phase change, distortion of structure by magnetic field; Blue phase. Chiral smectic phases, origin of ferroelectricity: Structure, symmetry and ferroelectric ordering in chiral smectic C phase; Antiferroelectric and ferroelectric chiral smectic C phase.

Application of Liquid Crystals.

Reference Books:

1. Liquid Crystals: S. Chandrasekhar.

2. The Physics of Liquid Crystals: P.G. de Gennes and J Prost.
3. Liquid Crystals, Fundamentals: S Singh.

MPE-407: Computational Physics **Credits: 3**

Stochastic Processes
Theory of random walks and simulation of random walks in one, two and three dimensions. Elementary ideas and simulations of self-avoiding walks, additive and multiplicative stochastic processes, Brownian motion and fractional Brownian motion

Percolation theory
Percolation theory and simulation by Hoshen-Kopelman algorithm; Application to simple lattice models in Physics

Simulations of physical models
Elementary ideas of: (a) Time-average and Molecular dynamics: Dynamical equations and physical potentials; Verlet algorithm (b) Ensemble average and Monte Carlo methods; Metropolis algorithm. Introduction to the simulations of: (a) Ising model in magnetism (b) Bak-Tang-Wiesenfeld model in studies of self-organized criticality

Combinatorial optimization problems
Classification of problems; examples of optimization problems: traveling salesman problem (TSP) and satisfiability (k-SAT) problem; heuristic methods of solutions and simulated annealing technique.

References

1. Understanding Molecular Simulation (Academic Press), D. Frenkel & B. Smit
2. Introduction to Percolation Theory (Taylor-Francis), D. Stauffer
3. Equilibrium Statistical Physics (World Scientific), M. Plischke & B. Bergersen
4. Numerical Recipes in C: The Art of Scientific Computing (Cambridge University Press), W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling

MPL-401(A): ELECTRONICS LABORATORY **Credits: 6**

Students will be required to perform six (06) experiments of the following, other than those performed in Semester-III:

1. Microwave characteristics and measurements
2. Nonlinear applications of Op amplifier
3. PLL characteristics and its applications
4. PAM, PWM and PPM Modulation and demodulation.
5. PCM / delta modulation and demodulation
6. Fiber optic communication
7. Experiments on MUX, DEMUX, Decoder and shift register
8. Arithmetic operations using microprocessors 8085 / 8086
9. D/A converter interfacing and frequency / temperature measurement with microprocessor 8085 / 8086
10. A/D converter interfacing and AC/DC voltage / current measurement using microprocessor 8085/8086
11. PPI 8251 interfacing with microprocessor for serial communication.
12. Assembly language program on P.C

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-401(B): NUCLEAR PHYSICS **Credits: 6**

Students will be required to perform seven (07) experiments of the following, other than those performed in Semester III:

1. Gamma - Ray Spectroscopy Using NaI (Tl) detector.
2. Alpha Spectroscopy with Surface Barrier Detector.
3. Determination of the range and energy of alpha partcles using spark counter.
4. Study of gamma ray absorption process.

5. X-Ray Fluorescence.
6. Neutron Activation Analysis Measurement of the Thermal Neutron Flux.
7. To Study the Solid State Nuclear Track Detector.
8. Fission Fragment Energy Loss Measurements from Cf^{252}.
9. Gamma - Gamma Coicidence studies.
10. Compton Scattering: Energy Determination.
11. Compton Scattering: Cross-Section Determination.
12. Determination of energy of mu-mesons in pi-decay using Nuclear Emulsion Technique.
13. Identification of particles by visual range in Nuclear Emulsion.
14. Study of Rutherford Scattering.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

PL-401(C): SPECTROSCOPY LABORATORY **Credits: 6**

Students will be required to perform six (06) experiments of the following, other than those performed in Semester III:

1. Verification of Hartmann formula for prism spectrogram
2. Measurement of optical spectrum of an alkali atom
3. Determination of metallic component of an inorganic salt
4. Emmiter of electric discharge through air in a tube with minute leak
5. Emitter of electric discharge through air in an evacuated tube
6. Measurement of optical spectrum of alkaline earth atoms.
7. Measurement of Band positions and determination of vibrational constants of AlO molecule
8. Measurement of Band positions and determination of vibrational constants of N_2 molecule
9. Measurement of Band positions and determination of vibrational constants of CN molecule
10. Measurement and analysis of fluorescence spectrum of I_2 vapour
11. Determination of characteristic parameters of an optical fiber
12. Measurement of Raman spectrum of CCl_4.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-401(D): SOLID STATE PHYSICS LABORATORY **Credits: 6**

Students will be required to perform four (04) experiments of the following, other than those performed in Semester III:

1. Measurement of lattice parameter and indexing of powder photograph
2. Identification of unknown sample using powder diffraction method.
3. To study the ferroelectric transition in TGS crystal and measurement of Curie temperature.
4. To measure the superconductivity transition temperature and transition width of a high temperature superconductor.
5. Rotation / oscillation photograph and their interpretation.
6. To study the modulus of rigidity and internal friction in a metal as a functioning temperature.
7. To measure the Cleavage step height of a crystal by multiple Fizeau Fringes.
8. To determine magnetoresistance of a Bismrith crystal as a function of magnetic field.
9. Synthesis/ Fabrication of Carbon Nanotubes by spray paralysis method and its verification through X-ray diffraction.

Note: Addition and deletion in the list of experiments may be made from time to time by the department**.**

MPD-401: PROJECT AND DISSERTATION **Credits: 2**

The dissertation topics will be based on special papers or elective papers and topics of current interest. A departmental committee will distribute the topics.

M.A. / M.Sc. PSYCHOLOGY
Department of Psychology
Banaras Hindu University

DISTRIBUTION OF DIFFERENT COURSES AND CREDITS IN VARIOUS SEMESTERS

Semester-I			
Course Code	**Title**	**Credits**	
PSM 101	Attention and Perceptual Processes	4	
PSM 102	Research Methods and Experimental Designs	4	
PSM 103	Advanced Physiological Psychology	4	
PSM 104	Applied Social Psychology	4	
PSM 105	Practicals	3	
PSM 106M #	Minor Elective: Basic Psychological Process (for the students of other PG Programmes) Minor Elective (for Psychology Students)	3	
	Total	22	
Semester-II			
PSM 201	Language, Memory and Thinking	4	
PSM 202	Non-experimental & Correlational Methods	4	
PSM 203	Psychobiology	4	
PSM 204	Cross-cultural Psychology	4	
PSM 205	Practicals	3	
PSM 206 #	Minor Elective: Applications of Psychology in Human Life (for the students of other PG Programmes) Minor Elective (for Psychology Students)	3	
	Total	22	
Semester-III			
PSM 301	Applied Psychological Assessment	4	
PSM 302	Affective Processes	4	
PSM 303	Diagnostic Techniques/ Organisational Behaviour/ Child Development /Comparative Psychology	4	
PSM 304	Psychopathology/ Stress-Management/ Child Psychopathology/ Psychopharmacology	4	
PSM 305	(a)Practicals (b) Comprehensive Viva-Voce	2 1	3
PSM 306 #	Minor Elective: Stress Management (for the students of other PG Programmes) Minor Elective (for Psychology Students)	3	
	Total	22	
Semester-IV			
PSM 401	Therapeutic techniques/Human Resource Management/Psychology of Adolescence	4	
PSM 402	Neuro-Psychology/Organisational Development & Change/Psychology of Adulthood & Ageing.	4	
PSM 403	Psychology of Personality/ Psychology of Rehabilitation/Organisational Communication/Psychology of Sports	4	
PSM 404	Health Psychology/Drugs and Behaviour/Counselling/Human Factors	4	
PSM 405	Practicals	3	
PSM 406	Comprehensive Viva-Voce	3	
	Total	22	
	Grand Total	88	

M.A./M.Sc. Psychology students will opt 3 minor electives (of 3 credits each in Semester I, II, & III) offered by the Department of Psychology.

Semester I

PSM 101 Attention and Perceptual Processes

1. Cognitive approach: Origin and current status of cognitive psychology
2. Attention: Concepts and mechanisms;
   Selective attention: Bottleneck theories, capacity model and automaticity.
   Sustained attention: Psychophysical factors and theories
3. Perception: Figure-ground organization, figure formation, and psychophysics of form. Non-veridical perception
4. Space, time and movement perception: Theoretical perspectives
5. Perceptual development. Nature-nurture controversy: Pre-exposure, deprivation and enrichment.
6. Cognitive and motivational influences on perception: Instruction, target identification and perceptual defence, perception without awareness.

Books Recommended

Best, J. B. (1999). *Cognitive psychology* (5th ed), Belmont, CA: Brooks/Cole
Dember, W.N.& Warm, J. S. (1979). *Psychology of perception* (2nd ed). New York: Holt
Howard, D,B. (1983) *Cognitive psychology*. New York: McMillan.
Mattlin, M. W. (1995). *Cognition.* (3rd edition).Bangalore: Prism Books
Schiffman, H.R. (1996). *Sensation and perception: An integrated approach*. New York: John Wiley
Solso, R.L. (2001) *Cognitive psychology*. (6th ed). Singapore: Pearson Education

PSM 102 Research Methods and Experimental Designs

1. Scientific approach in psychology and theory building;
   Types of research: Experimental and ex-post facto;
   Ethical issues in psychological research.
2. Problem and hypothesis: Origin and sources, special features
   Variables: Operational definition, criterion and predictor variables ,
   selection, manipulation and control of independent and extraneous variables, measurement of dependent variables and threats to valid measurement.
3. Sampling: Meaning, purpose and types
   Factors influencing sampling decisions: Size, accessibility and cost.
4. Research design: Meaning, characteristics and purpose, criteria of good design. Between groups designs: Equivalent groups, randomized groups, multilevel, factorial (2x2) and multifactor designs,
   Within groups designs: Within subjects design, one-group repeated trial, randomized block design (within the same subject), N = I design, two-factors within subjects design.
5. Statistics: Testing of hypotheses, substantive and null hypothesis. Statistical inferences: -'t' test, Chi-square test, analysis of variance factorial ANOVA with two or more variables.
   Multiple range tests: Tukey, Duncan, and Newman-Keuls.

Books Recommended

Broota, K. D. (1989). *Experimental designs in behavioural research*. New Delhi; Wiley Eastern.
Edwards, A. L. (1968). *Experimental designs in psychological research* (3rd ed). New Delhi: Oxford and IBIL.
Heiman, G. W. (1995) *Research methods in psychology*. Bostol1: Houghton Miffin Co.
Kerlinger, F.N. (1973). *Foundation of behavioural research* (2nd ed) Delhi: Sanjeet Publications.
Kopala, M., & Suzuki L.A. (1999). *Using qualitative methods in Psychology* (2nd ed). Thousand Oaks: Sage.
Siegel, S., & Castellon (1988). *Non-paramatic statistics for the behavioural sciences* (2nd ed). New York: McGraw Hill.
Winer, B.J ., Brown D.R., & Michels, .K.M. (1991). *Statistical principles in experimental designs* (3rd ed). New York: McGraw Hill

PSM 103 Advanced Physiological Psychology

1. Organization and functions of the central nervous system: Spinal cord, hindbrain, midbrain and forebrain
2. Methods of physiological psychology: Invasive physiological methods; Methods of visualizing the living human brain; Recording human psychophysiological activity.
3. Neural conduction and transmission: Resting membrane potential; Action potential; Synaptic transmission; Neuromuscular transmission: Information processing.
4. Hemispheres of the neocortex: Role of corpus callosum and anterior commissure; Split-

brain; Hemispheric dominance; Capabilities of right hemisphere; Lateralization of language; Neuroplasticity.

5. Hormones and the brain: Endocrine communication and pheromone communication

Books Recommended:

Brodal P. (1992) .*The central nervous system: Structure and function*. New York: Oxford University Press
Carlson, N.R. (2000). *Physiology of behaviour*. Boston: Allyn & Bacon.
Ganong, W.F.(2002) *Review of medical physiology*. Norwalk, C.T: Appleton & Lange
Guyton, A. C. (2000). *Text book of medical physiology*. philadelphia: W.B. Saunders Comp.
KaIat, J. W. (2001) *Biological psychology*. C.A.: Wadsworth
Nicholls, J.G. , Martin, A.R.,Wallace, B.G. and Fuchs, P.A. (2000) *From neuron to brain*, Sunderland, MA: Sinauer

PSM 104 Applied Social Psychology

1. Present trends in social psychology: Approaches to the study of social behaviour. General framework of applied social psychology.
2. Social disadvantage and deprivation: Disadvantaged .groups, indicators and measurement, psychological consequences, remedial and intervention programmes.
3. Environmental issues: Noise, pollution and atmospheric conditions; Density and crowding; Response to environmental challenges; Intervention for environmental management.
4. Health and well-being: Conceptual issues, biomedical and psycho-social models of health, ealth impairing behaviours; Health promotion and invention programmes.
5. Aggression and violence: Conceptual issues and theoretical explanations; Determinants; Interpersonal and intergroup forms of aggression; Strategies for reducing aggression and violence.
6. Population and gender issues: Economic and psycho-social models of population; Population growth; Dynamics and consequences; Control strategies. Problems of women, perceptions and discriminations, women empowerment strategies.

Books Recommended:

Alcock, .J.E., et al. (1998). *A textbook of social psychology*. Scarborough, Canada:Prentice Hall.
Baron, R.A. & Byrne, D. (2000). *Social psychology*. New Delhi: Prentice Hall
Misra, G. (Ed.) (1990). *Applied social psychology in India*. New Delhi: Sage.
Mohanty, A. K., Misra, G. (2000). *Psychology of poverty and disadvantage*. New Delhi: Concept.
Oskamp, S. (1984) *Applied social psychology*. Englewood Cliffs, N.J. Prentice Hall
Semin, G., & Fiedler, K. (1996). *Applied social psychology*. London: Sage.

PSM 105 Practical

Any six of the following experiments:

1. Masking effects by noise inducements.
2. Geometric illusion- perspective theory study.
3. Absolute judgement of positions on a line.
4. Signal detectability.
5. Selective attention -response selection.
6. Sustained attention: temporal and spatial uncertainty.
7. Target recovery by backward masking.
8. Depth perception -pictorial cues.
9. Reversible perspective.
10. Perceptual defence -autonomic discrimination without awareness.
11. Chronometric analysis of perceptual vigilance.
12. Time perception.
13 Set in perception.
14. Effect of instruction on perception.
15. Perceptual differentiation.
16. Gender stereotype
17. Health beliefs.
18. Perception of environment.

Minor Elective

PSM 106M: Basic Psychological Processes Credits: **3**

1. Psychology : Nature and scope
1. Perceptual processes: Sensation, perception and attention.
2. Learning: Principles and processes.
3. Memory and forgetting: Process and measurement. Forgetting.
4. Emotion and Motivation: Nature and types.
5. Intelligence: Concept and measurement; emotional intelligence.
6. Personality: Concept and measurement.

Books recommended:

1. Atkinson, R. L., Atkinson, R. C., & Hilgard, E. R. (1998). Introduction to psychology, (10th edition), New York: Harcourt Brace Jovanovich.
2. Baron, R. A. (2006). Psychology (5th edition). New Delhi: Pearson Education.
3. Ciccarelli, S. K., & Meyer, G. E. (2007). Psychology (1st edition). New Delhi: Pearson Education.
4. Feldman, R. (2004). Understanding Psychology (6th edition). New Delhi: McGraw Hill
5. Gerrig, R. J., & Zimbardo, P. G. (2006). Psychology and Life (17th edition). New Delhi: Pearson Education.
6. Morgan, C. T., King, R. A., Weisz, J. R., & Schopler, J. (1986). Introduction to psychology (7th edition) Bombay: Tata-McGraw Hill.
7. Singh, R. N. (2005). Adhunik samanya manovigyan. Agra: Vinod Pustak Mandir.
8. Singh, A.K. (1997). Uchchtar samanya manovigyan. Varanasi: Motilal Banarasi Das.

PSM 201 Language, Memory and Thinking

1. Language structure: Grammar and linguistics. Chomsky's theory: Empirical support for deep-surface-structure distinction, neurology and language structure.
2. Speech and language perception: Perceiving and comprehending speech. Reading.
3. Language acquisition and cognitive development: Stages in language development, conceptual basis of language and the theory of mind
4. Memory storage models: Sensory, short-term and long-term storages. Working memory : Levels of processing approach; Procedural, episodic and semantic memory. Flashbulb, autobiographical and eye-witness memory; Implicit and explicit memory.
5. Reasoning and decision making: Logical, formal and natural reasoning. Decision making: Heuristics and framing decisions
6. Problem solving: Typology of problems; Newell-Simon theory; Tactics for solving problems: Problem space, means-end analysis, analogy, operators, sub- goal analysis, and working backward

Books Recommended

Anderson, J. R. (1995). *Learning and memory: An integrated approach*. New York: John Wiley.
Baddeley, A.D. (1986). *Working memory*: Oxford: Oxford University Press.
Baddeley, A. D, (1990). *Human memory: Theory and practice*. Boston: Allyn & Bacon.
Best, J. B. (1999). *Cognitive psychology* (5th Ed), Belmont, CA: Brooks/Cole.
Mattlin, M. W. (1995). *Cognition*. (Third Edition).Bangalore: Prism Books
Solso, R.L. (2004). *Cognitive psychology* (6th ed). New Delhi: Pearson Education.

PSM 202 Non-Experimental and Correlational Methods

1: Quasi- experimental designs:
One group designs, non-equivalent control group, and time series designs.
2. Correlational designs:
Panel design, cross-sectional and longitudinal designs.
3. Qualitative methods:
Qualitative and quantitative perspectives;
Collecting qualitative data: Case study, interview, observation method.
Discourse analysis, grand narrative analysis, ethnographic methodology.
4. Concept and application of Multiple Regression Analysis (linear and stepwise),
Factor analysis: Techniques and implications.
Discriminant function analysis: Techniques and interpretation.
Non-parametric statistics: Median test, Wilcoxen test, Mann- Whitney U-test, Kolmogorov-Smirnov one and two sample tests, Kruskal- Wallis H test, Kendall's coefficient of concordance. Friedman two-way analysis of variance.
5. Introduction to statistical analysis through computers

Books Recommended

Breakwell, G.M., Hammond, S., & Fife-Schaw, C. (2000). *Research methods in psychology* (2nd ed.).London: Sage Publications.

Broota, K. D. (1989). *Experimental designs in behavioural research*. New Delhi: Wiley Eastern.

Edwards, A. L. (1968). *Experimental designs in psychological research* (3rd edition).New Delhi: Oxford and IBH

Flick, U. (2002). *An introduction to qualitative research*. Landon: Sage Publications

Kerlinger, F.N. (1973). *Foundation of behavioural research* (2nd edition). Delhi: Sanjeet Publications.

Kopala, M. & Suzuki, L.A. (1999). *Using qualitative methods in psychology* (2nd edition). Thousand Oaks: Sage.

Siegel, S. & Castellon (1988). *Non-paramatic statistics for the behavioural sciences* (2nd edition). New York: McGraw Hill

Smith, J.A. (Ed) (2003). *Qualitative psychology: A practical guide to research methods*.London: Sage Publication

Winer, B.J., Brown D.R. & Michels, K.M. (1991). *Statistical principles in experimental designs* (3rd edition). New York: McGraw Hill

PSM 203 Psychobiology

1. Emotion: Somatic and visceral feedback, ANS and emotion, endocrine and emotion, neural mechanisms of emotion. Stress and health
2. States of consciousness: Physiological and behavioral correlates of sleep, arousal and alertness; Disorders of arousal and sleep.
3. Learning and memory: Locus of the memory trace, changes at the synapse in learning, neural structures involved in learning and memory; Biochemical basis of memory
4. Neurophysiological diseases, causes of brain damage and effects
5. Drugs and behaviour: Principles of drug action. Characteristics of psychoactive drugs: Alcohol, barbiturates, marijuana, nicotine, caffeine, cocaine, amphetamine, opiates. Neural mechanism of addiction

Books recommended:

Bloom, F.L. & Lazeron, A: (1996). *Brain mind and behaviour*: New York: Freeman & Co.

Kolb, B. & Whishaw, I.Q. (1996). *Fundamentals of human neuropsychology*. New York: W.H.Freeman & Co.

Mana, (1999). *Biopsychology.* Boston:Allyn & Bacon

Pinel P.J. (2000). *Biopsychology.* Boston: Allyn & Bacon.

Zaidel, D.W. (1994) *Neuropsychology*, New York, Academic Press.

PSM 204 Cross- Cultural Psychology

1 Culture and behaviour: Nature of culture; Cultural relativety and universality of human behaviour; Mechanism of cultural transmission.

2. Methodology of cross-cultural psychology: Comparability and equivalence; Universals, emics and etics; Sampling and measurement issues; Back translation, decentring and subsystem validation.
3. Culture and cognition: Theoretical positions, contemporary issues, cultural influences on perception, cognition, learning, memory, problem solving, reasoning and creativity; Everyday cognition.
4. Culture and emotion: Basic emotions, dimensional and componential models, subjective experiences, appraisal, physiological reaction and emotional expressions.
5. Cultural change and adaptations: Processes of enculturation and acculturation in plural societies; Acculturation strategies; Acculturation and adaptation of tribal people and refugees; Behaviour shifts and acculturative stress.

6 Cross-cultural communication: Verbal and nonverbal interactions; Communication incongruence; Deceptions, cultural display rules; Promoting intercultural interaction.

Books Recommended:

Berry, J.W, Poortinga, Y.H., Segall, M. H., & Dasen, P. R. (2002). *Cross-cultural psychology: Research and application*. New York: Cambridge University Press.

Berry, J. W. et al, (Eds). (1997). *Handbook of' cross-cultural psychology* (2nd Edition) (Vol 1-3), Boston: Allyn & Bacon.

Brislin, R. (Ed.) (1990). *Applied cross-cultural psychology*. Newbury Park: Sage

Matsumoto, D. (2001). *The handbook of culture and psychology*. New York: Cambridge University Press.

Segall, M. H., Dasen, P. R., Berry, J. W., & Poortinga, Y. H. (1999), *Human behaviour in global perspective*, Boston: Allyn & Bacon.
Triandis H.C. et al. (Eds.) (1980). *Handbook of cross-cultural psychology*, (Vol.1-6). Boston: Allyn & Bacon,

PSM 205 Practical

Any six of the following:
I. Planning of a correlational study.
2. Semantic differential technique
3. Q-sort methodology.
4. Narrative analysis.
5. Preparation of all interview schedule.
6. Case study.
7. Short term memory
8. Levels of processing
9. Episodic Memory
10. Semantic memory.
11. Formal Reasoning.
12. Problem solving.
13. Translation and back translational of a scale.
14. Achievement construct in cultural/ ethnic groups.
15. Psychological differentiation.
16. Classification of objects! pictures.
17. Acculturative stress.
18. Syllogistic reasoning.

Minor Elective

PSM 207M: Applications of Psychology in Human Life

Credits: **3**

1. Applied psychology: Nature and scope
2. Guidance and counseling: Nature and techniques.
3. Psychology in education: Pedagogic techniques; creativity.
4. Mental health and well-being: Concept and indicators; techniques for improving mental health and well-being.
5. Psychopathological problems: Neurotic and psychotic disorders.
6. Application of psychology in social life: Prejudice and stereotypes; socially deviant behaviour: Crime and delinquency; Drug addiction.

Books Recommended:

1. Rastogi, G. D. (1992). Vyavaharik manovigyan. Agra: Har Prasad Bhargava.
2. Singh, A. P. (1995). Vyavaharik monovigyan. Varanasi: Abhishek publications.
3. Anastasi, A. (1979). Fields of applied psychology. New Delhi: McGraw Hill.
4. Goldstein, A. P., & Krasner, B. (1987). Modern applied psychology. Elmford, New York: Pergmon Press.
5. McCormick, E.J., & Ilgen, D. (1980). Industrial psychology. Englewood Cliffs, N.J.: Prentice Hall.

Semester III

PSM 301(Compulsory) Applied Psychological Assessment

1. Meaning and Purpose of Psychological Assessment: Principles of assessment; Ethical considerations.
2. Developing interview schedules, questionnaires, rating scales and surveys for assessment of specific problems related to clinical, organizational and educational settings with practical exercises: Main problems in developing instruments.
3. Administration of Instruments: Categorization, coding and scoring of data; Reliability of categories, codes and scores.
4. Analysis of Data: Qualitative data analysis, quantitative data analysis and social statistics.
5. Interpretation of Data: Evaluation, judgment, and biases.
6. Research Report: Stops involved in presenting research report.

Books Recommended:

Babbie, E. (2004). *The practice of social research*. Singapore: Thomson Asia.
Ciminaro, A. R. (1984). *Handbook of behavioral assessment*. New York: Wiley.

Fowler, F.J. Jr. (2002). *Suevey research methods*. Thousands Oaks: Sage.
Henry, G.T. (1995). *Graphing data.* Newbury Park: Sage.
Holstein, J.A. & Gubrium, .F.(1995) *Active interview*. London : Sage.
Leung, F.T.L. & Austin, J.T. (1996). *The psychological research handbook*. London: Sage.
Miller, D.C. (1991). *Handbook of research design and social instrument*. London: Sage.

PSM 302 (Compulsory) Affective Processes

1. Affective Processes: Nature and properties; Origin, development and present status. Ethologist's contribution.
2. Motivation: Conceptual issues; Response dimension. Homeostasis.
3. Theoretical Framework: Murray and Maslow systems, intrinsic and extrinsic framework. Techniques of assessment: Unobtrusive, self- report and projective.
4. Emotion: Conceptual and theoretical issues, Differences in emotional expression, genetics, culture and personality.
5. Biological and Neurophysiological Approaches to Emotion: Emotional network in the brain, psychophysiology of emotion.
6. Emotional Intelligence: Framework, assessment and application.

Books Recommended:

Cofer, C. N. & Appley, M. H. (1964). *Motivation: Theory and research.* Delhi: Wiley Eastern.
Lewis, M., & Haviland-Jones, J. M. (2000). *Handbook of emotions*. NewYork: Guilford Press.
Singh, D (2003). *Emotinal intelligence at work.* New Delhi: Sage
Weiner, B. (1998). *Human motivation*. Newbury Park: Sage.

PSM 303 (Optional): Diagnostic Techniques

1. Psychodiagnostics: Nature and scope. Sources of clinical data: The assessment interview; behavioural assessment, ratings and checklists; Psychological tests. Differential diagnosis.
2. Case Study: Levels of assessment in case study and case study guide.
3. Psychological Interviewing: Structured interviewing; Intake interviewing; Mental status examination and diagnostic interviewing; Crisis interviewing.
4. Intelligence Testing; Standford–Binet: fourth edition, WAIS- III/WAIS- R scales.
5. Personality Testing: Self-report inventories-MMPI-2 and NEO PI-R. Projective tests: TAT and Rorschach with specific indicators for neuroses and schizophrenia.
6. Neuropsychological Testing: Bender-Gestalt and Wechsler Memory Scale- Revised.

Books Recommended:

Cullari, S. (Ed.) (1998). *Foundations of clinical psychololgy*. Boston: Allyn & Bacon.
Goldenberg, H. (1983). *Contemporary clinical psychology* (2nd Ed.) New York:Brooks & cole.
Kahn, T.C. & Giffen,(1960) M.B. *Psychological techniques in diagnosis and evalution*.Oxford: Pergmon Press.
Neitzel, M.T. , Bernstein, D.A., & Millich, R. (1998). *Introduction to clinical psychology*. (5th Ed.) Upper Saddle River, N.J. : Prentice Hall.
Wolman, B.B. (1978). *Clinical diagnosis of mental disorders: A handbook*. New York: Plenum.

PSM 303 (Optional) Organizational Behaviour

1. Nature and Scope of Organizational Behaviour: Historical background, approaches challenges and opportunities, contributing disciplines
2. Organizational Structure and Design: Nature, organizational designs, behavioural implications of different organizational designs
3. Interactive Conflict and Negotiation skills: Intra-individual, interpersonal, inter-group conflicts, organizational conflicts, negotiation skills.
4. Leadership: Trait, behaviour, contingency, and contemporary theories, leadership styles and skills, roles and activities.
5. Power and Politics in Organizations: Bases of Power, Power tactics, Politics: Power in action, factors contributing to political behaviour.
7. Organizational Culture : Nature and types, creating and maintaining culture.

Books Recommended:

*Luthans, F. (1998).*Organizational Behaviour (8th ed.*). New York: McGraw Hill.*
Riggio, R. E. (2003). *Introduction to Industrial/Organizational Psychology* (4th ed.). Upper Saddle River, NJ: Prentice-Hall.
Robbins, S. (2004). *Organizational Behaviour*. New York: Pearson Education.
Wexley, K.N. & Yukl, G.A. (1977*). Organizational Behavior and Personnel Psychology.* Homewood, Illinois: Irwin.

PSM 303 (Optional) Child Development

1. Concept of Development: Principles of growth, maturation and development. Developmental stages.
2. Determinants of Development: Biological and socio-cultural.
3. Prenatal Development: Stages and factors affecting it.
4. The Neonate: Physical characteristics, reflexes, sensory and motor capacities.
5. Development During Infancy: Physical and motor development; Sensory and perceptual development; Language, emotional and social development.
6. Development During Childhood: Cognitive, social, emotional and moral emergence of self.

Books Recommended:

Berk, L.E. (2003), *Child development*. New Delhi: Prentice Hall.
Bhutt, G.(1990). *Vikasatmak manovigyan*, Delhi: Delhi University.
Dworetzky J.P. (1984). *Introduction to child development* (2nd ed.). St. Paul: West Publishing Co.
Hurlock, J.B.(1997). *Child psychology*. (Hindi & English Versions).
Kaluger, G.S., & Kaluger, M.F.(1984). *Human development: The span of life*, (3rd Ed.). St.. Louis: Times mirror.
Santrock, J.W.(1999). *Life-span development*, New York: McGraw Hill.
Seifert K.L. & Hoffnung R.J. (1991) *Child and adolescent development*. New York: Houghton Mifflin Co.
Shaffer, D.R. (1996). *Developmental psychology*. California: Brooks / Cole.

PSM 303: (Optional) Comparative Psychology

1. Methods of Comparative Psychology : Paradigms for the assessment of species common behaviors, conditioning paradigms, seminatural animal learning paradigms.
2. Assessing the Effects of Drugs: Pharmacological considerations; Behavioral considerations.
3. Evolution of brain and behaviour.
4. Life-span development of the brain and behavior.
5. Animal models of anxiety, depression and aggression.

Books Recommended:

Alcock, J.A. (2001). *Animal behavior: An evolutionary approach* (7th ed.) Sunderland, M.A: Sinauer.
Dewsbury, D.A. (1990) *Contemporary issues in comparative psychology*. Sunderland, M.A: Sinauer
Drickamer, L.C., Vessey, S.H. & Miekle, D. (1995) *Animal behavior: Mechanisms, ecology ,evolution.* New York: Mc Graw Hill Higher Education.
Finger S.(1994) *Origins of neuroscience*. New York: Oxford University Press.
Futuyma, D.J. (1998), *Evolutionary biology* (3rd ed.) Sunderland, MA: Sinauer.
Krebs, J.R. and Davies, N.B. (Eds.) (1997) *Behavioral ecology*: *An evolutionary approach.* Cambridge, MA: Blackwell Science.
Maier, R. (1997).*Comparative animal behavior : An evolutionary and ecological approach.*New York: Allyn & Bacon.
Malin, T., Birch, A., & Hayward, S.(1996). *Comparative psychology.London: MacMillan.*
Mellgren, R.L. (1983) *Animal cognition and behavior.* Amsterdam: North-Holland Publishing Co.

Plomin, R.(1990) *Nature and nurture : An introduction to human behavioral genetics*. Pacific Grove, CA: Brooks /Cole.
Shettleworth, S.A. (1998), *Cognition, evolution and behaviour*. New York: Oxford University Press.
Trivers, R.L. (1985). *Social evolution*. New York :Benjamin Cummings Publishing Co.

PSM 304 (Optional) : Psychopathology

1. Classification Systems in Psychopathology: Early diagnostic classification systems. ICD 10, DSM -IV
2. Approaches to Psychopathology: Biological, psychodynamic, behavioral, cognitive, socio-cultural.
3. Anxiety Disorders: Approaches and etiology of generalized and anxiety disorder, panic disorder, phobia obsessive-compulsive disorder and post- traumatic stress disorders.
4. Somatoform Disorders: Approaches and etiology of somatization, hypochondriasis, pain disorder and conversion disorder.
5. Psychotic Disorders: Approaches and etiology of schizophrenia, paranoid and mood disorders.
6. Cognitive Impairments: Approaches and etiology of delirium, dementia and amnestic syndromes, Dementia of the Alzheimer's type, presenile dementia, Pick's disease, Huntington's chorea.

Books Recommended:

Barlow, D.H. & Durand, V.M. (1999). *Abnormal psychology: An integrative approach(2nd Ed.)*. Pacific Grove: Brooks/Cole.
Buss. A.H. (1999). *Psychopathology*. New York :John Wiley.
Carson, R.C., Butcher, J.N., & Mineka, S.(2001) *Abnormal psychology in modern life* (11Ed). New York. Allyn and Bacon
Davison, G.C. & Neals J.M. (1996) *Abnormal psychology* (Revised Ed.). New York: John Wiley.
Kaplan, H.I., Saddock, B.J. & Gribb, J.A. (1994) *Synopsis of psychiatry*. New Delhi. B.I Waruly.
Lamm. A.(1997). *Introduction to psychopathology*. New York : Sage.
Sue, R., Sue., D., & Sue, S (1990). *Understanding abnormal behavior*. Boston: Houghton Mifflin.

PSM 304 (Optional) Stress Management

1. Organizational Stress**:** Concept- different perspectives, symptoms, individual factors influencing job stress.

2. Causes of Job Stress**:** Personal characteristics, organizational structure and change, properties of work and work setting, job role, machine pacing and shift work.

3. Consequences of Job Stress**:** Job behaviour, job satisfaction, performance, absenteeism; health strains-physical illness, mental/ psychological symptoms.

4. Stress Management Interventions**:** Individual centred- cognitive, behavioural, physical. Organization centred-preventing, mitigating and moderating organizational stressors.

5. Coping with Stress**:** Types of coping strategies

6. Therapeutic Approaches to Stress Management **:** Hypnosuggestive, philosophical hypnosis, self talk, music therapy.

Books Recommended:

Mattson, M.T. & Ivanevich, J.M. (1987) *Controlling work stress- Effective resources and management strategies*.
Pestonjee, D.M. (1992) *Stress and coping*. New Delhi: Sage Publications,.

Ross, R. R. & Altmair, E.M. (1994). *Interventions in occupational stress*. New Delhi: Sage Publications
Srivastava, A.K. (1999) *Management of occupational stress: Theories and practice.* New Delhi: Gyan Publishing House

PSM 304 (Optional) Child Psychopathology

1. Childhood Psychopathology: Historical overview. Models: Medical, behavioural, psychodynamic, cognitive, and developmental.
2. Approaches to Classification: Descriptive-behavioural, descriptive-inferential, dynamic-etiological, DSM-IV.
3. Specific Disorders in Children: Attention deficit hyperactivity disorder, learning disability and mental retardation: Symptoms and causes.
4. Neurotic Disorders: Childhood compulsive, obsessive and phobic reactions.
5. Childhood Psychosis: Autism and childhood schizophrenia: Symptoms and causes.
6. Mood Disorders: Depression and mania: Symptoms and causes

Books Recommended:

Clarizio, H.F.& McCoy, G.F. (1983) *Behavior disorder in children*. New York: Harper & Row.
Karkar, S. (1981) *The inner world: A psycho-analytic study of childhood and society in India*. Delhi: Oxford University Press.
Mash, E.J. & Barkly, R.A. (Eds.) (1996) *Chlid psychology*. New York: Guilford Press.
Quay, H.L. & Werry, J.S. (Eds.) (1986) *Psychological disorders of childhood.* New York: John Wiley.
Weiner, I.B. (1982) *Child and adolescent psychopathology*. New York: John Wiley.
Wenar, C. (1982) *Psychopathology from infancy through adolescence: A developmental Approach*. New York: Random House.

PSM 304 (Optional) Psychopharmacology

1. Determinants of Drug Effect: Absorption, distribution, and termination of drug effects
2. Responsiveness to Drugs: Organismic variables, drug variables, environmental variables, and task variables.
3. Classification of psychoactive drugs and their effects.
4. Psychopharmacological methods of studying the nervous system.
5. Biopsychological paradigms of animal and human behavior.
6. Nature and functioning of neurotransmitters and neuropeptides in the brain.

Books Recommended:

Carlson, N.R.(2000*). Physiology of behavior* . Boston: Allyn and Bacon.
Cooper, J.R., Bloom,F.E. & Roth, R.H. (2002*). The biochemical basis of neuropharmacology*. London: Oxford University Press.
Julien, R.J. (2000). *A primer of drug action* (7th ed.) New York: Freeman
Leavitt, F.(1982). *Drugs and behavior*. New York : John Wiley & Sons.
Marangell, L.B., Martinez, J.M., Silver, J.M., & Yudofsky, S.C. (2002) *Conciseguide to psychopharmacology* New York: American Psychiatric Association.
McKim, W.A. (1986). *Drugs and behavior : An introduction to behavioral pharmacology* . Englewood Cliffs, N.J.: Prentice –Hall.
Pies, R.W. (1998). *Handbook of essential psychopharmacology*. New York: American Psychiatric Association.
Pinel, P.J. (2000) *Biopsychology*. Boston : Allyn and Bacon.
Seiden, L.S. & Blaster, R.L. (1985). *Behavior pharmacology: The current status*. New York : Arliss.
Zaidel, D.W. (1994). *Neuropsychology*. New York : Academic Press.

PSM 305 (a) Practicals

Applied Psychological Assessment

(Any two of the following)

1. Construction of Interview schedules

2. Construction of Questionnaires
3. Construction of Rating Scales
4. Conduct of Surveys

Affective Processes
(Any two of the following)
1. Extrinsic motivation and performance
2. Intrinsic motivation and performance
3. Feedback and performance
4. Assessment of emotional intelligence

Diagnostic Testing
(Any one of the following)

1. Rorschach Test (1 normal and 1 psychopathological case)
2. T.A.T. (1 normal and 1 psychopathological case)
3. NEOPIR (1 normal and 1 psychopathological case)
4. Case studies (1 normal and 1 pathological case)

Organizational Behaviour
(Any one of the following)
1. Conflict resolution
2. Job involvement
3. Leadership/supervision
4. Functional Social Support

Child Development
(Any one of the following)
1. Raven's Progressive Matrices.
2. Psychomotor learning.
3. Emotional control.
4. Gessell's / Bailey's scale for assessment of growth in infants.

Comparative Psychology
(Any one of the following)
1. Maze- learning
2. Reasoning behaviour
3. Discrimination learning
4. Level of activity

Psychopathology
(Any one of the following)

1. Rorschach /T.A.T. / S.I.S (1 normal & 1 psychopathological case)
2. Measurement of Neuroticism (2 cases)
3. Measurement of Psychotic Traits (2 cases)
4. DSM IV Diagnostic Criteria (2 cases)

Stress Management
(Any one of the following)
1. Assessment of stress (questionnaire)
2. Coping strategies
3. Functional Job stress
4. Stress Resistant (Cognitive, Behavioural)

Child Psychopathology
(Any one of the following)
1. Study of ADHD (1 case)

2. DSM -IV Diagnostic criteria for children (2 cases)
3. Childhood depression (2 cases)
4. Assessment of Mental Retardation using Form Boards/ Bender- Gestalt test.

Psychopharmacology

(Any one of the following)

1. Effects of drugs on exploratory behaviour in albino rats.
2. Effects of drugs on simple learning in albino rats.
3. Effects of drugs in Staircase test.
4. Effects of drugs in elevated T-maze test.

PSM 305 (b) Comprehensive Viva- Voce

Minor Elective

PSM 306M: Stress Management **Credits: 3**

1. Stress: Nature of stress, physiology of stress, stress affects on human conditions.
2. Physiological, somatic, psychological and behavioural effects of stress.
3. The factors contributing to stress reactions; environmental factors and living conditions; and job-related stress.
4. Coping strategies
5. Constructive stress management: Controlling stressors; proactivity; the importance of awareness (self-monitoring); interpretation and perception.
6. Stress management techniques: Somatic, behavioural and cognitive.

Books Recommended:

1. Gluch, P. (2005). Stress management (2nd edition). Costa Mesa, CA: Psynergy Publication.
2. Greenberg, J. S. (2006). Comprehensive stress management (10th edition). New York: McGraw Hill.
3. Olpin, M, & Hesson, M. (2007). Stress management for life: A research base experiential approach. Belmont, CA: Thomson Learning.
4. Pestonjee, D. M. (1992). Stress and coping. New Delhi: Sage Publications.
5. Ross, R. R., & Altmair, E. M. (1994). Interventions in occupational stress. New Delhi: Sage Publications.
6. Srivastava, A. K. (1999) Management of occupational stress: Theories and practice. New Delhi: Gyan Publishing House.

PSM 401 (Optional) Therapeutic Techniques

1. Nature and techniques of psychotherapy: The client- therapist relationship; Ethical issues.
2. Psychopharmacological therapy: Overview of major psychotropic drug classes.
3. Psychodynamic therapy: Freudian psychoanalysis
4. Behavior therapy: Guided exposure, systematic desensitization, eye movement desensitization and reprocessing, aversion therapy, assertion training, modelling, biofeedback.
5. Cognitive behaviour therapy: Beck's cognitive therapy, rational emotive behaviour therapy.
6. Humanistic-experiential therapy: Person-centred therapy, gestalt therapy, existential therapy, transactional analysis.
7. Interpersonal relationship therapy: Marital and family systems therapy.

Books Recommended:

Corey, G. (2001). *Theory and practice of counselling and psychotherapy*. (6th ed.) Belmont, C.A: Brooks/Cole.

Culari, S. (1998) (Ed.) *Foundations of clinical psychology*. New York: Allyn & Bacon.

Goldenberg, H. (1983) *Contemporary clinical psychology* (2nd ed.). New York: Brooks /Cole

Hersen, M, & Sledge, E. (2002) (Eds.). *Encyclopedia of psychotherapy*. (TwoVolumes). New York: Academic.

Neitzel, M.T., Bernstein, D.A. & Millich, R. (1998) *Introduction to clinical psychology* (5th ed.) Upper Saddle River, New Jersy: Prentice Hall.

PSM 401(Optional) Human Resource Management

1. Fundamentals of HRM: Foundation, nature, scope and importance. HRM in changing environment.
2. Acquisition of human resources: Planning, assessment, job analysis, recruiting, selection process.
3. Training and development: Socialization process, determining training needs, management development.
4. Performance appraisal: Performance management system, appraisal process, methods, creating effective personnel management system.
5. Motivation and reward management: Theoretical perspectives, job design, work scheduling, types of reward, establishing pay structure, compensation and benefits.
6. Labour relations: Labour-management relations, unionism, collective bargaining.

Books Recommended:

Beardwell, I & Holden, L. (1996). *Human resource management: A contemporaryperspective.* New Delhi: Macmillan India Ltd.

Bhatia, S.K., & Singh, N. (2000). *Principal techniques of personnel management/ human resource management*(2nd ed). New Delhi: Deep & Deep Publications Pvt. .Ltd.

DeCenzo, D.A., & Robbins, S.P.(1999) *Human resource management*(6th ed.). New York: John Wiley.

Dwivedi, R.S. (1997) *Managing human resources: Personnel management in Indian enterprises.* New Delhi: Galgotia Publishing Company.

Hersey, P. Blanchard, K.H. & Johnson, D.E. (1996) *Management of organizational behavior*: *Utilizing human resource* (7th ed.). New Delhi: Prentice Hall of India Pvt.Ltd.

PSM 401 (Optional) : Psychology of Adolescence

1. Concepts of puberty and adolescence; Developmental tasks during adolescence.
2. Physical changes during early, mid and late adolescence. Perception and reaction to physical changes.
3. Cognitive and moral development: Piaget's, Kohlberg's and Loevinger's models.
4. Social development: Achieving independence from parents. Parent- peer conflicts and development of relationships.
5. Personality development: Identity formation and emotional characteristics.
6. Stressors and problems of adolescence: Suicidal behaviour, drug abuse, teenage parenthood, juvenile delinquency.

Books Recommended:

Berk, L.E. (2003*). Child development*. New Delhi: Prentice Hall.

Berzonsky, M. D. (1981). *Adolescent development*. New York: Macmillan.

Chauhan, S.S. (1983). *Psychology of adolescence*. New Delhi: Allied.

Dworetzky, J.P. (1984). *Introduction to child development.*St. Paul: West Publishing Company.

Kaluger, G., & Kaluger, M.F. (1984). *Human development: The span of life*. St. Louis: Times Mirror.

Rice, F.P. (1993). *The adolescent: Development relationships and culture* (7th ed.). Boston: Allyn and Bacon.

Seifert, K.L., & Hoffnung, R.J. (1991). *Child and adolescent development* (2nd ed.). NewYark: Houghton & Mifflin Co.

Shaffer, D.R. (1996). *Developmental psychology and adolescence* (4thed.). California: Brooks & Cole.

Verma, S. & Saraswati, T.S. (2002). *Adolescence in India: An annotated bibliography*. Jaipur: Rawat Publication.

PSM 402 (Optional) Neuropsychology

1. Assumptions, Methods; Functional modularity, anatomical, functional architecture, and substractivity.
2. Organization of the Brain: Cerebral cortex and its lobes; Hemispheres and related structures.
3. Cognitive Neuropsychology: Neurological basis of attention and consciousness; vigilance and cortical arousal.
4. Measurement of Brain Activity: EEG, QEEG, ERP; CT Scan, MRI, PET, fMRI; Neurological assessment (Luria Nebraska Neurological Battery, Halstead-Reitan Test).

5. Neurological Disorders: Vascular disorders; traumatic head injury; epilepsies; tumors; degenerative disorders; Prion Disease.
6. Abnormal Lobular Functions: Frontal lobe syndrome; Temporal lobe syndrome; Parietal and Occipital lobe syndrome.

Books Recommended:

Beatty, J. (2001). *The human brain: Essentials of behavioral neuroscience*.Thousand Oaks: Sage Publication, Inc.

Boller, F., & Grafman, J. (1998). *Handbook of neuropsychology*. New York: Elsevier.

Chalupa, L.M. & Werner, J.S. (2004). *The visual neurosciences.* London: MIT Press

Gazzaniga, M.S. (2002). *Cognitive neuroscience: The biology of mind* (2nd Ed.). New York: W.W. Norton and Company.

Kolb, B., Whisaw, I.Q. (1990). *Fundamentals of neuropsychology*. New York: Freeman, W.H.

Naatanen, R. (1992). *Attention and brain function*. Hillsdale: LEA

Parsuraman, R. (1998). *Attentive brain.* London: MIT Press.

Rapp, B. (Ed.) (2001). *The handbook of cognitive neuropsychology*. Chestnut Street: Psychology Press.

Paper S4:02(Optional) Organizational Development and Change

1. Introduction to organizational development: Nature and characteristics, historical development; Process of management of change.
2. Management of organizational development: Foundations, process and action research.
3. Organizational development interventions: Team, third-party, comprehensive, structural interventions, and training experiences.
4. Management of change: Organizational structure, organizational culture, employee relations and involvement strategies.
5. Evaluating change and future of organizational development.

Books Recommended:

Bennis, W.C. (1969) *Organization development: Its nature, origins, and prospects.* Reading, MA: Addison-Wesley

Colenso, M. (2001) *Successful organizational change: Evolution and revolution in the organization.* New York: Prentice Hall.

French, W. L. & Bell, C. H. (1995). *Organization development*. New York: Prentice Hall. McGill, M. E. *Organization development for operating managers.*

Nilakant, V. & Ramanarayan, S. (1998). *Change management*. New Delhi: Response Books.

Ramnarayan, S., Rao, T.V. and Singh, K. (1998). *Organization development: Interventions and strategies*. New Delhi: Response Books.

Thornhill, A., Lewis, P. Millmore, M., & Saunders, M. (2000), *Managing Change: A human resource strategy approach*. New York: Pearson Education.

S4:02 (Optional) Psychology of Adulthood and Aging

1. Concept, characteristic features and developmental tasks of adulthood and aging; Aging in India.
2. Theoretical approaches: Biological: Genetic, cellular and physiological; Psychological: Erikson and Peck; Social: Role theory, activity vs. disengagement theory; Indian theory of Ashramas.
3. Changes and coping with changes in adulthood and aging: Physical aspects, cognitive functions, personality and concept of self, social aspects.
4. Significant concerns in adulthood: Choosing a career, marriage, family, successful parenting, coping with midlife crisis, work and pre-retirement planning.
5. Significant concerns for aging persons: Retirement, living arrangement, grand parenting, coping with bereavement and death, and loneliness.

6. Factors leading to positive mental health in adulthood, longevity and successful aging.

Books Recommended:

Birren, J.E. (1996). *Encyclopedia of gerontology (Vol I & II).* California: Academic Press

Botwinick, J. (1973). *Aging and behaviour.* New York: Springer Publication Co.

Hurlock, J.B. (1997). *Developmental psychology-The life span perspective* . New York: McGraw Hill Co.

Kaluger, G., & Kaluger, M.F. (1984). *Human development-The span of life.* St. Louis: Times Mirror.

Palmore, B.E. (1993). *Developments and research on aging: An international handbook*. Westport: Greenwood Press.

Rao, V.A. (1989). *Psychology of old age in India*. Madras: MacMillan India Press.

PSM 403 (Optional) Psychology of Personality

1. Personality: Concept and scope; Basic issues related to study of personality.
2. Trait and type approaches : Allport, Cattell, Eysenck and five factors model.
3. Psychodynamic and psychosocial approaches : Freud and Erikson
4. Behaviouristic and social learning approaches: Skinner, Bandura and Mischel.
5. Humanistic and phenomenological approaches: Rogers and Kelly.
6. Determinants of Personality: Biological-physiological and genetic; Environmental –socialization, society and culture.

Books Recommended:

Friedman, H.S. & Schustack, M.W. (2003). *Personality: Classic theory and modern research* (2nd ed.) Singapore: Pearson Education.

Hall, G.C., Lindzey, G., & Campbell, J.C. (1998). *Theories of personality*, (4th ed.). New York: Wiley.

Hjelle, L.A. & Zeigler, D.J. (1991). *Personality theories: Basic assumptions, research and applications*. (2nd ed.) New York: McGraw Hill.

Mischel, W. (1976). *Introduction to personality*. New York: Holt Reinhart & Winston.

Pervin, A. (1984). *Personality:Theory and research*. New York: John Wiley & Sons.

PSM 403(Optional) Psychology of Rehabilitation

1. Introduction : Definition, nature and rationale of rehabilitation.
2. Impairment and disability. Incidence and prevalence of various disabilities..
3. Assessment of Disabilities: Basic principles of assessment and evaluation. Types of assessment- norm based, criterion based and function based, Psychological tests as screening and assessment tools.
4. Rehabilitation Techniques: Basic principles of intervention, types of intervention-individual, group and family based. Vocational counselling, behavioural therapeutic approaches in rehabilitation.
5. Perspectives of rehabilitation services: Settings and agencies involved in rehabilitation services.
6. Government schemes and policies for rehabilitation: The role of NGOs. Legislation and legal aspects, policies and acts. Ethical issues in rehabilitation.

Books Recommended:

Advani, S.L., Ghate, P. Goel, H.C., & Reddy, V.R.L. (2002). *Foundation course on education of children with disability*. Hyderabad: G.Guru Publications

Kundu, C.L. (2000). *Status of disability in India*. New Delhi: Rehabilitation Council of India.

Narain, J & Kutty, A.C. T (1990). Skill *training for M R persons*. Hyderabad:J.S. Graphics.

Peshawaria, R. (1994). *Moving forward*. Hyderabad: J.S. Graphics.

Stromer, D.C.& Prout (1995) (Eds.). *Counselling and psychotherapy for persons with mental retardation and borderline intelligence*. Vermont: Clinical Psychology Publishing Co.

Verma, L. (1990). *The management of children with emotional and behavioural difficulties*. London: Routledge.

PSM 403 (Optional) Organizational Communication

1. Conceptual framework: Meaning and process of communication, models and perspectives of communication in organizations. ethical Issues.

2. Communication within oganizational structures: Structural issues, direction of communication flow, communication barriers, communication networks, external communication.
3. Interpersonal communication: Interpersonal communication in formal relationships- needs perspective, transactional analysis, johari window; Role of symbols, media and information technology, choosing among media.
4. Non-verbal communication: Dimensions and functions of non-verbal communication, cultural differences in nonverbal communication.
5. Communication in groups: Group structure and communication networks, developing effective work groups, models of communication in group decision making.
6. Communication for organizational effectiveness: Persuasion and influence, counselling, listening, orientation and feedback, conducting effective interviews, effective oral presentations, forms of written communication.

Books Recommended:

Andrews, P.H. & Herschel, R.T. (1997) *Organizational communication.* (1st ed.). New Delhi: A.I.T.B.S. Publishers

Fisher, D. (2003*) Communication in organizations*(2nd ed.). Bombay: Jaico Books

Lesikar, R.V. & Pettit, J.D. (1998) *Business communication: Theory and applications. (6th ed.)*. IIinois: Richard D. Irwin Inc:

PSM 403 (Optional) Psychology of Sports

1. History and current status of Sports Psychology.
2. Growth and Development of Sports Persons – Concept of growth and development. Critical periods. Stages of psychomotor development of the athlete.
3. Cognitive Processes in Sports: Attention, perception, decision making.
4. Motivation in Sports: Motivational techniques. Emotions and Sports performance: Stress, anxiety and arousal and aggression in sports.
5. Personality and Sports – Personality traits of outstanding sports persons.
6. Psychosocial Dimensions of Sports: Sports as a social experience. Concept of team cohesiveness. Leadership and communication in Sports team. The role of sports psychologist. Spectators & Sports – Kinds and roles of spectators.

Books Recommeded:

Arnold, D.L.U. & Nation, J.R. (1989) *Sports psychology*. Chicago: Nalson-Hall

Cratty, B.J. (1989), *Psychology in contemporary sports*. N. J. Prentice Hall.

Horn, T.S. (Ed) (1992), *Advances in sports psychology*, Canada: Herman Kinetics.

Mohan, J. (1996), *Recent advances in sports psychology*: New Delhi: Friends.

Murphy, E. (1995), *Advances in sports psychology*, Illinois: Human Kinetics.

Murphy, S.M. (1995) *Sports psychological interventions*. Champaign: Herman Kinetics.

Sandhu, G.S. (1992) *Psychology in sports: A contemporary perspective*, New Delhi: Friends.

Sahani, S.P. (2001) *Handbook of sports psychology*.

PSM 404 (Optional) Health Psychology

1. Concept of health: Indicators; Medical and bio-psycho-social models of health; Cross–cultural perspectives on health; Main issues of health psychology and its social concerns.
2. Social environment and health: Global health trends; Health care systems, socio-economic factors in health; Gender and health.
3. Images of health: General and chronic health problems; Causal explanations and oral discourse; Health belief systems and models; Western and non-western perspectives on health.
4. Stress and coping: Stress as stimulus and response; Interaction model of stress; Stress born health problems.
5. Factors in health: Food, alcohol and drug consumption, smoking and sexual behaviours.
6. Management of health problems; Preventive, promotive and curative aspects of health; Choice of medicinal systems and patient-doctor relationship. Changing health behaviour.

Books Recommended:

Baum, A., Gatchel, R.J., & Krantz, D.S. (1997). *An introduction to health psychology*. New York: McGraw Hill.
Baum, A., Revenson, T.A., & Singer, J.E. (2001). *Handbook of health psychology*. Mahwah, N.J.: Lawrence Erlbaum.
Dimatteo, M.R. & Martin, L.R. (2002). *Health psychology*. Boston: Allyn & Bacon.
Marks, D., Murray, M., Evans, B., & Willig, C. (2000). *Health psychology : Theory,research and practice*. New Delhi: Sage.
Radley , M. (1994). *Health psychology: Bio-psycho-social interaction* . New York: John Wiley
Taylor, S.E. (1994). *Health psychology*. New York: Random House.

PSM 404 (Optional): Drugs and Behaviour

1. Pharmacology of learning & memory: The neurotransmitter systems, memory molecules and drug effects.
2. Aggression: Animal models of aggression. Influence of hormones and drugs in animals and human.
3. Sleep disorder and pharmacological treatment: Insomnia, hypersomnia and parasomnia.
4. Human and Nonhuman Sexual and reproductive functioning: Hormones and drugs effects.
5. Psychopharmacotherapy: Drug treatment of schizophrenia, depression, mania, anxiety and hyperkinetic behaviour.

Books Recommended:

Bloom, F.E. and Kupfer, D.(eds.). (1995) *Psychopharmacology: The fourth generation of progress.*New York : Raven.
Cooper, J.R., Bloom, F.E. and Roth, R.H. (1996). *The biochemical basis of neuropharmacology* (7^{th} ed.) New York : Oxford University Press.
Feldman, R.S., Meyer, J.S. and Quenzer, L.F. (1997). *Principles of neuropsychopharmacology*. Sunderland, MA : Sinauer.
Gazzaniga, M.S. (2000). *The new cognitive neurosciences.*
Gorman, J.M. (1995). *The essential guide to psychiatric drugs*. St. Martin's Press.
Julien, R.J. (2000). *A primer of drug action* (9^{th} ed.) New York: Freeman.
Kolb, B. and Whishaw, I.Q. (1996). *Fundamentals of human neuropsychology*. New York: W.H. Freeman & Co.
Rosenzweig, M.R., Breedlove, S.M., & Leiman, A.L. (2002). *Biological psychology*. Sunderland, MS: Sinauer Associates.
Spinella, M.(2001) *The psychopharmacology of herbal medicine: Plant drugs that alter mind, brain and behavior*. MIT Press.
Stahl, S.M. and Munter, N. (2000) *Essential psychopharmacology*: *Neuroscientific basis and practical applications*. Cambridge, England: Cambridge University Press.

PSM 404 (Optional): Counselling

1. Counselling: Historical perspective; Definitional models: Educational developmental and preventive; Ethical issues in counselling.
2. Expectations and goals of counselling: Characteristics of counselee and counselors; Role and functions of the counselors.
3. Counselling approaches: Affectively oriented approaches: psychoanalytic, person-centred and existential; Cognitively oriented approaches: Eclectic and behavioural.
4. Counselling process: External conditions and preparation; Structuring the counselling relationship; Counselling interview and degrees of lead by the counsellor, nonverbal behaviour; Group counselling approaches.
5. Areas of counselling: Educational, career, family and marital, gerontological and weaker sections; Stress management oriented counselling.
6. Evaluation of counselling: Nature and purpose, steps in evaluation, and outcome research.

Books Recommended:

Gelso, C.J., & Fretz, B.R. (1995) *Counselling psychology*. Bangalore: Prism Books Pvt. Ltd.
Locke, D.C.,Myers, J.E., & Herr, E.L.(eds.) (2001) *The handbook of Counselling*. Thousands Oaks, CA: Sage Publication Inc.

Patri, V.R. (2001) *Conselling psychology*. New Delhi: Authors Press.
Rao, S.N. (1991). *Counselling and guidance* (2nd ed.). New Delhi: McGraw Hill.
Shertzer, B. & Stone, S.C. (1968). *Fundamentals of counselling*. New York: Houghton Mifflin.
Woolfe, R., Dryden, W., & Strawbridge, S.(eds.) (2003) *Handbook of counselling psychology* (2nd ed.) London: Sage Publication Ltd.

PSM 404 (Optional) Human Factors

1. Human Factors: Definition, historical overview, models of human information processing, person-computer interface; video display terminal, interface design, and on-line help.
2. Human interaction with automation in various contexts: Automation definition, aircraft piloting, air-traffic control, automobiles and highway systems.
3. Human error: The man-machine interface: Approaches to human error, errors and accidents, error proneness and accident liability.
4. Human factors and health care: The promise of human factors in the medical devices, designing of WWW for older adults.
5. Human Performance in relation to automation: Monitoring performance, trust, situation awareness, mental workload.

Books Recommended :

Matthews, G., Davies, D.R., Westerman, S. J., &. Stammers, R. B.(2000). *Human performance.* Sussex, UK: Psychology Press.
Nickerson, R.S. (1992). *Looking ahead: Human factors challenges in a changing world.* Hillsdale: LEA.
Senders, J. W., & Moray, N. P. (1991). *Human error: cause, prediction, and reduction*. Hillsdale: LEA.
Sheridan, T. B. (2002). *Humans and automation*. CA: John Wiley
Singh, I.L., & Parasuraman, R. (1998) *Human cognition*. New Delhi: Sage Publications

PSM 405 (a) Practicals

Therapeutic Techniques

(Any one of the following)

1. Preparing hierarchy for systematic desensitization (1 case)
2. Biofeedback (1 case)
3. Transactional analysis –Script analysis
4. Geslalt therapy- Role playing

Human Resource Management

(Any one of the following)

1. Performance appraisal
2. Job analysis/Job evalution
3. Work motivation
4. Unionism

Psychology of Adolescence

(Any one of the following)

1. Self esteem
2. Moral development
3. Assessment of stress
4. Emotional maturity

Neuropsychology

(Any one of the following)

1. Cortical arousal and vigilance performance
2. Heart rate variability (HRV) and performance
3. Hemispheric specialization and performance
4. Assessment of brain activity by Luria Nebraska

Organizational Development and Change

(Any one of the following)

1. Organizational climate
2. Psychological participation

3. Personal efficacy scale
4. Organizational culture

Psychology of Adulthood and Ageing

(Any one of the following)

1. Parenting style among adults
2. Self concept among adults.
3. Adjustment / life satisfaction among elderly
4. STM vs LTM process among elderly.

Personality

(Any one of the following)

1. Personality assessment using any projective test
2. Semantic differential
3. NEO P I –R test
4. T.P.P.S/16 P.F

Psychology of Rehabilitation

(Any one of the following)

1. Assessment of social anxiety in orthopedically challenged persons. (1 case)
2. Assessment of self-esteem in visually challenged (1 case)
3. Assessment of paranoid thought content in hearing impaired (1 case)
4. Family based intervention (1 case)

Organizational Communication

(Any one of the following)

1. Transactional analysis
2. Interviewing
3. Communication patterns in public/ private sector
4. Listening orientation

Psychology of Sports

(Any one of the following)

1. Sports competitive anxiety test
2. Biofeedback
3. Reaction time/design making time
4. Personality test

Health Psychology

(Any one of the following)

1. Socio-economic factors and health
2. Gender and health
3. Psychological correlates of health
4. Drug/ smoking and health problems/Pathogenic health habits

Drugs and Behaviour

(Any one of the following)

1. Effects of drugs on elevated plus-maze test in albino rats.
2. Effects of drugs on discrimination learning in albino rats.
3. Effects of drugs on anxiety in albino rats.
4. Effects of drugs on acquired-fear in albino rats.

Counselling

(Any one of the following)

1. Conducting counselling interviews (2 cases)
2. Educational counselling at secondary level (1 case)
3. Assessment of career related stress (2 cases)
4. Group counselling in school setting.

Human Factors

(Any one of the following)

1. Vigilance and monitoring performance
2. Workload and human performance
3. Automation reliability and performance
4. Person- computer interface

S4:05 (b) Comprehensive Viva- Voce

M.Sc. STATISTICS
Department of Statistics
Banaras Hindu University

FOUR SEMESTER POST - GRADUATE COURSE

STATISTICS

1. The Post Graduate Course in STATISTICS shall be Two – Year Degree Course comprising of FOUR SEMESTERS (Two Semesters in each year). The total credits including all the four semesters will be 90 including Minor Elective Papers.

2. There shall be sessionals / tutorials / class tests / seminars in class / group discussions in each theory and practical paper (Core Courses, Major and Minor Elective papers) except Paper No. STM - 417 : Project Work – II in Semester – IV.

3. Each theory paper, irrespective of their nature and credits shall be of 100 marks out of which 70 marks shall be assigned to the end semester theory examination and 30 marks to the sessionals / tutorials / class tests / seminars in class / group discussions.

4. The Theory papers shall be of THREE HOURS duration consisting of Eight full length questions in all out of which a student will be required to answer any five questions.

5. Each Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce .

6. All the practical papers shall be of FOUR HOURS duration.

7. In the paper " Research Methodology and Project Work – I" (Paper No. STM - 303) in Semester – III, there will be a theory paper of 70 marks and the rest 30 marks will be assigned to the preparation of project proposal, discussion and its presentation.

8. In semester – IV, the Project Work – II (Paper No. STM - 417) will be spread over the whole semester. A project may be undertaken by a group of students. However, the project report shall be submitted by each member of the group separately. A project report shall clearly state the problem addressed, the methodology adopted, the assumptions and the hypotheses formulated, any previous reference to the study undertaken, statistical analyses performed and the broad conclusion drawn. There shall be an external examiner and an internal examiner (preferably the supervisor of the student) for the evaluation of the project work. Out of total 100 marks assigned to the project, 60 marks will be assigned on the evaluation of the project work separately by both the examiners and 40 marks will be assigned jointly by the examiners on the oral presentation and viva – voce.

9. If a student offers four major elective papers from the same module, he/she will be certified to have specialized in that module.

10. The three MINOR ELECTIVE THEORY papers (one in each of the semesters – I , II and III) will be offered by the students of other departments of the faculty, who are not pursuing Post – Graduation in Statistics.

Semesterwise distribution of Courses and Credits

SEMESTER - I

Course Code	Title	Credit
STM – 101	Real Analysis, Complex Analysis and Linear Algebra	3
STM – 102	Distribution Theory	4
STM – 103	Statistical Inference - I	4
STM – 104	Statistical Computing	4
STM – 105	Practical Paper based on the contents of Papers STM – 103 and STM - 104	3
STM106M	Statistical Methods (Minor Elective for students of other programmes) *	3
	Total	**21**

SEMESTER - II

STM – 201	Survey Sampling	3
STM – 202	Linear Models and Regression Analysis	3
STM – 203	Statistical Inference – II	3
STM – 204	Stochastic Processes	3
STM – 205	Probability	3
STM – 206	Practical Paper based on the contents of Papers STM – 201 and STM - 203	2
STM – 207	Practical Paper based on the contents of Papers STM – 202 and STM - 204	2
STM 208M	Sampling Theory, Design of Experiments and Data Analysis Using Softwares (Minor Elective for students of other programmes) *	3
	Total	**22**

SEMESTER - III

STM– 301	Multivariate Analysis	3
STM – 302	Design and Analysis of Experiments	3
STM – 303	Research Methodology and Project Work – I	2
Any THREE papers out of the Paper Nos. STM – 304 to STM - 308		
STM – 304	Statistical Decision Theory	3
STM – 305	Advanced Operations Research - I	3
STM – 306	Survival Analysis	3
STM – 307	Computer Intensive Statistical Methods - I	3
STM – 308	Time Series Analysis	3
STM – 309	Practical Paper based on the contents of Papers STM – 301, STM – 302 and selected Major Elective Papers	4
STM308M	Data Analysis Using Regression Models (Minor Elective for students of other programmes) *	3
	Total	**24**

* Students of Statistics shall offer Minor Electives from other programmes.

SEMESTER - IV

Course Code	Title	Credit
Any SIX papers out of the Paper Nos. STM – 401 to STM – 415		
STM – 401	Bayesian Inference	3
STM – 402	Non – Parametric and Semi – Parametric Methods	3
STM – 403	Applied Regression Analysis	3
STM – 404	Reliability Theory	3
STM – 405	Advanced Operations Research – II	3
STM – 406	Statistical Processes and Quality Control	3
STM – 407	Demography	3
STM – 408	Quantitative Epidemiology	3
STM – 409	Clinical Trials	3
STM – 410	Computer Intensive Statistical Methods – II	3
STM – 411	Computer Programming	3
STM – 412	Statistical Pattern Recognition	3
STM – 413	Econometrics	3
STM – 414	Actuarial Statistics	3

STM – 415	Official Statistics	3
STM – 416	Practical Paper based on the contents of selected Elective papers	3
STM – 417	Project Work – II	2
	Total	**23**
	GRAND TOTAL	**90**

The optional Papers of III and IV Semesters are divided into following five groups :
GROUP A : ADVANCED STATISTICAL ANALYSIS

Major Electives

Paper No.		Title of the Paper
STM - 304	:	Statistical Decision Theory
STM – 401	:	Bayesian Inference
STM – 402	:	Non - Parametric and Semi - Parametric Methods
STM – 403	:	Applied Regression Analysis

GROUP B : INDUSTRIAL STATISTICS AND OPERATIONS RESEARCH

Major Electives

STM – 305	:	Advanced Operations Research – I
STM – 404	:	Reliability Theory
STM – 405	:	Advanced Operations Research – II
STM – 406	:	Statistical Process and Quality Control

GROUP C : BIOSTATISTICS

Major Electives

STM – 306	:	Survival analysis
STM – 407	:	Demography
STM – 408	:	Quantitative Epidemiology
STM – 409	:	Clinical Trials

GROUP D : COMPUTATIONAL STATISTICS

Major Electives

STM – 307	:	Computer Intensive Statistical Methods – I
STM – 410	:	Computer Intensive Statistical Methods – II
STM – 411	:	Computer Programming
STM – 412	:	Statistical Pattern Recognition

GROUP E : ECONOMIC AND FINANCIAL STATISTICS

Major Electives

STM – 308	:	Time Series Analysis
STM – 413	:	Econometrics
STM – 414	:	Actuarial Statistics
STM – 415	:	Official statistics

Note : If a student offers FOUR major Elective Papers from the same Group, he / she will be certified to have specialized in that Module.

There shall be sessionals / tutorials / class tests / seminars in class / group discussions in each theory and practical paper except Paper No. STM – 417 : Project Work – II in Semester – IV.
Each theory paper, irrespective of their nature and credits shall be of 100 marks out of which 70 marks shall be assigned to the end semester theory examination and 30 marks to the sessionals / tutorials / class tests / seminars in class / group discussions. The Theory papers shall be of THREE HOURS duration consisting of Eight full length questions in all out of which a student will be required to answer any five questions
Each Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out

of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce . The duration of the paper shall be FOUR HOURS).

.Semester I

STM – 101 : REAL ANALYSIS, COMPLEX ANALYSIS AND LINEAR ALGEBRA Credits : 3

Recap of elements of set theory, introductions to real numbers, open and closed intervals (rectangles), compact sets, Bolzano-Weirstrass theorem.

Sequence and series, their convergence, real valued function, continuous functions, Uniform continuity, sequences of functions, Uniform convergence.

Differentiation, maxima-minima of functions, functions of several variables, multiple integrals, change of variables in multiple integration, uniform convergence in improper integral.

Complex numbers, Analytic function, Cauchy fundamental theorem, Cauchy integral theorem, Contour integrations.

Vector spaces, sub-spaces, linear dependence and independence, orthogonalization process, orthonormal basis

References :

1. Apostol, T.M. (1985): Mathematical Analysis, Narosa Indian Edn.
2. Miller, K.S. (1957): Advanced Real Calculus, Harper, New York.
3. Ruddin, Walter (1976): Principles of Mathematical Analysis, McGraw Hill.
4. Shanti Narain: A Course in Mathematical Analysis, S. Chand and Company (Pvt.) Ltd.
5. Graybill, F.A. (1983): Matrices With Applications in Statistics, 2nd Ed. Wadsworth.
6. Searl, S.R. (1982): Matrix Algebra for Statistical, John Wiley and Sons inc.,
7. Rao, C.R. and Mitra, S.K. (1971): Generalized Inverse of Matrices and its Application, John Wiley and Sons Inc.
8. Halmos, P.R. (1958): Finite Dimensional Vector Speces, 2nd ed. Van. Nortrand Company Inc.
9. Shanti Narain: A text book of matrices, S. Chand and Company (Pvt.) Ltd.

STM – 102 : DISTRIBUTION THEORY Credits : 4

Brief review of basic distribution theory, joint, marginal conditional p.m.f.'s and p.d.f's, standard discrete and continuous distributions, bivariate normal, bivariate exponential, multivariate normal and multinomial distributions, functions of random variables and their distributions using Jacobian of transformation and other tools.

Compound, truncated and mixture distributions, conditional expectation, multiple and partial correlations, linear and multiple regressions. Markov, Holder, Jensen, Liapunov inequalities.

Sampling distributions, non-central chi-square, t and F distributions and their properties. distributions of quadratic forms under normality and related distribution theory.

Order statistics, their distributions and properties, joint and marginal distributions of order statistics, extreme values and their asymptotic distributions (statement only) with applications. approximating distributions Delta method and its applications, approximating distributions of sample moments, transformations of statistics.

References :

1. Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematics Statistics, Wiley International students edition.
2. Rohatagi, V.K. (1984): An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
3. Rao, C.R. (1973); Linear Statistical Inference and its Applications, Wiley Eastern.
4. Pitman, J. (1993): Probability, Narosa Publishing House.
5. Jonson, S. and Kotz, S. (1972): Distribution in Statistics Vol. I-II & III, Houghton and Mifflin.

STM – 103 : STATISTICAL INFERENCE – I Credits : 4

Extension of Cramer-Rao inequality for multi-parameter case, Bhattacharya bounds, information in data about the parameters as variation in likelihood function.

Ideas of sufficient and minimal complete-sufficient statistics, sufficiency when the range of variate depends on parameter, minimum variance unbiased estimators, Rao-Blackwell and Lehman-Scheffe theorems, examples based on some standard distributions.

Asymptotic properties of maximum likelihood estimators, solution of likelihood equations, method of scoring, Newton-Raphson method.
General decision problems, loss function, risk function, estimation and testing viewed as general decision problems, minimax decision, Bayes decision, least favourable prior, Bayes estimation under squared error loss, some simple illustrations based on binomial, Poisson, and normal distributions, procedure for obtaining minimax estimators from Bayes estimators.

References :

1. Kale, B.K. (1999): A First Course on Parametric Inference, Narosa Publishing House.
2. Rohatgi, V.K. (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
3. Lehmann, E.L. (1986): Theory of Point Estimation, Student Edition.
4. Lehmann, E.L.(1986): Testing Statistical Hypotheses, Student Editions.
5. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
6. Ferguson, T.S. (1967): Mathematical Statistics, Academic Press.
7. Zacks, S. (1971): Theory of Statistical Inference, Wiley, New York.

STM – 104 : STATISTICAL COMPUTING **Credits : 4**

Programming in a high level such as C (preferred) or FORTRAN. The purpose of this unit is to introduce programming with the eventual aim of developing skills required to write statistical software. Topics should include simple syntax, loops, pointers and arrays, functions, input/output, and linking to databases.

Numerical analysis and statistical applications. The purpose of this unit is to apply programming skills in methods and alogrithms useful in probability, statistics, and data analysis. Topics should include numerical integration, root extraction, random number generation, Monte Carlo integration, and matrix computations.

A statistical package such as SAS, or SPSS. The purpose of this unit is to use a statistical package to carry out statistical procedures already known to students. No 'new' statistical methods should be presented but interesting data can be analyzed using known methods on the package. Topics should include graphics, descriptive statistics, representation of multivariate data, simple hypothesis tests, analysis of variance.

References :

1. B.W. Kernighan and D.M. Ritchie (1988): The C Programming Language, Second edition, Prentice Hall.
2. W.H. Press, S.A. Teukolsky, W.T. Vellering, and B.P. Flannery (1993): Numerical Recipes in C, Second edition, Cambridge University Press.
3. B. Ryan and B.L. Joiner (2001). MINITAB Handbook, Fourth edition, Duxbury.
4. R.A. Thisted (1988): Elements of Statistical Computing, Chapman and Hall.

STM– 105 : Practical paper based on the contents of Papers Statistical Inference – I (STM - 103) and Statistical Computing (STM – 104) **Credits : 3**

Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce . The duration of the paper shall be FOUR HOURS).

STM106M : STATISTICAL METHODS **Credits : 3**

Descriptive Statistics : Measures of central tendency, dispersion, skewness and kurtosis for the study of nature of data.

Idea of correlation and regression for two and three variables; correlation coefficient, correlation ratio, multiple and partial correlations.

Important statistical distributions : Binomial, Poisson, hypergeometric, negative binomial, normal, uniform, exponential and multinomial distributions.

Statistical Inference : concepts of point estimation, interval estimation and testing.

References :

1. Bhat, B. R., Srivenkataramana, T. and Rao Madhava, K. S. (1996) : "Statistics : A Beginner's Text" Vol. I & II, New Age International (P) Ltd.
2. Snedecors, G.W. and Cochran, W.G. (1967) : "Statistical Methods", Iowa State university Press.

3. Goon, A.M., Gupta, .K. and Dasgupta, B. (1991) : "Fundamentals of Statistics" Vol. I, World Press, Calcutta.
4. Parzen, E. (1960) : "Modern Probability Theory and Its Applications", Wiley Eastern.
5. Mukhopadhyay, P. (1996) : "Mathematical Statistics", New Central Book Agency.
6. Hogg, R.V. and Craig, A.T. (1972) : "Introduction to Mathematical Statistics", Amerind Publishing Co.
7. Spiegel, M.R. (1967) : "Theory and Problem of Statistics", Schaum's Publishing Series.
8. Freund, J.E. (2001) : "Mathematical Statistics", Prentice Hall of India.

Semester II

STM – 201 : SURVEY SAMPLING **Credits : 3**

Fixed population and super-population approaches. Distinct featues of finite population sampling, Probability sampling design and estimators along with basic statistical properties. Review of some important results in SRSWOR and SRSWR. Estimation of population mean/Total in stratified population, Allocation problem in stratified random sampling in case of fixed cost and also for specified precision. Expression for variance of stratified sample mean in case of fixed cost, Post stratification, Double sampling with post stratification, Deep stratification, Controlled sampling.

Unequal probability sampling: PPSWR/WOR methods (including Lahiri's scheme) and Des Raj estimator, Murthy estimator (n=2). Horvitz Thompson Estimator of a finite population total/mean, Expression for V (HTE) and its unbiased estimator, Issue in non-negative variance estimation.

IIPS Scheme of sampling due to Midzuno-Sen, Double sampling scheme, Some double sampling estimators for mean using auxiliary character (Ratio, regression and product) method of estimation, Some unbiased ratio type estimators for population mean, Concept of cluster sampling, two stage sampling, interpenetrating sub-sampling, Two phase sampling.

Non-sampling error with special reference to non-response problems, Some well-known randomised response techniques for sensitive characteristics.

References :

1. Cassel, C.M., Sarndal, C.E. and Wretman (1977): Foundation of Inference in Survey Sampling, Wiley Inter Science, New York.
2. Choudhari A. and Vos, J.W.E. (1988): Unified Theory of Strategies of Survey Sampling, North Holland, Amsterdam.
3. Hedayat, A.S. and Sinha, B.K. (1991): Design and Inference in Finite Population Sampling, Wiley.
4. Murthy, M.N. (1977): Sampling Theory and Methods. Statistical Publication Society, Calcutta.
5. Mukhopadhyay, P. (1996): Inferential Problems in Survey Sampling, New Age International (P).
6. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and Indian Society of Agricultural Statistics.
7. Chaudhuri, A. and R. Mukherjee (1988): Randomised response: theory and techniques, New York, Marcel Deckker Inc.
8. Cochran, W.G.: Sampling Techniques (3^{rd} edition. 1977), Wiley.
9. Singh D. and Chaudhary, F.S. (1986): Theory and Analysis of Sample Survey Designs, New Age International Publishers.

STM – 202 : LINEAR MODELS AND REGRESSION ANALYSIS **Credits : 3**

Grauss-Markov linear models, estimable functions, error and estimation space, normal equations and least square estimators, estimation of error variance, estimation with correlated observations, properties of least square estimators, generalized inverse of a matrix and solution of normal equations, variances and covariances of least square estimators.

One way and two-way classifications, fixed, random and mixed effects models. Analysis of variance (two-way classification only), Multiple comparison tests due to Tukey, Scheffe and Student-Newmann-Karl.

Simple linear regression, multiple, regression, fit of polynomials and use of orthogonal polynomials. Residuals and their plots as tests for departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers. Remedies.

Multi co-linearity, ridge regression, sub-set selection of explanatory variables, Mallows C_P Statistics.

References :

1. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1967): An Outline of Statistical Theory, Vol. 2, The World Press Pvt. Ltd., Calcutta.
2. Rao, C.R. (1973); Linear Statistical Inference and its Application, Wiley Eastern.
3. Graybill, I.A. (1961): An Introduction to Linear Statistical Models, Vol. 1, McGraw Hill Book Co. Inc.
4. Draper, N.R. and Smith H. (1998); Applied Regression Analysis, 3rd Ed. Wiley.
5. Weisberg, S. (1985): Applied Linear Regression, Wiley.
6. Cook, R.D. and Weisherg, S. (1982): Residuals and Inference in Regression, Chapman and Hall.

STM – 203 : STATISTICAL INFERENCE – II **Credits : 3**

Consistent Asymptotic normal estimators and their properties, CAN estimators obtained by ML method in one parameter exponential case, Invariant estimators, location and scale invariant estimators, Pitman's method for obtaining location and scale invariant estimators.

Interval estimation by confidence sets, Neyman theory, general method for constructing confidence intervals, shortest confidence intervals, uniformly most accurate intervals, Bayes intervals, example based on normal distribution.

Neyman-Pearson lemma, generalized Neyman-Pearson lemma, monotone likelihood ratio families, UMP tests for one and two sided alternatives, admissibility and unbiasedness of tests, type A and type A_1 tests, similar tests, tests having Neyman structure, likelihood ratio test (LRT) asymptotic distribution of LRT statistic.

Wald's sequential probability ratio test and its properties, OC and ASN function, derivation of OC and ASN functions.

References :

1. Kale, B.K. (1999): A First Course on Parametric Inference, Narosa Publishing House.
2. Rohatgi, V.K. (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
3. Lehmann, E.L.(1986): Testing Statistical Hypotheses, Student Editions.
4. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
5. Ferguson, T.S. (1967): Mathematical Statistics, Academic Press.
6. Zacks, S. (1971): Theory of Statistical Inference, Wiley, New York.
7. Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematics Statistics, Wiley International students' edition.

TM – 204 : STOCHASTIC PROCESSES **Credits : 3**

Introduction to stochastic processes (SPs): Classification of SPs according to state space and time domain. Countable state Markov chains (MC's), Chapman-Kolmogorov equations; calculation of n-step transition probability and its limit. Stationary distribution, classification of states; transient MC; random walk and gambler's ruin problem; Applications from social, biological and physical sciences.

Discrete state space continuous time MC: Kolmogorov – Feller differential equations; Poisson process, birth and death process; Wiener process as a limit of random walk; first-passage time and other problems.

Renewal theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem; study of residual life time process. Stationary process; weakly stationary and strongly stationary processes; Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size. Martingale in discrete time, inequality, convergence and smoothing properties. Statistical inference in MC and Markov processes.

References :

1. Adke, S.R. and Manjunath, S.M. (1984): An Introduction to Finite Markov Processes, Willey Eastern.

2. Bharat, B.R. (2000): Stochastic Models: Analysis and Applications, new Age International, India.
3. Cinlar, E. (1975): Introduction to Stochastic Processes, Prentice Hall.
4. Feller, W. (1968): Introduction to Probability and its Applications, Vol. 1, Wiley Eastern.
5. Harris, T.E. (1963): The Theory of Branching Processes, Springer-Verlag.
6. Hoel, P.G., Port, S.C. and Stone, C.J. (1972): Introduction to Stochastic Processes, Houghton Miffin & Co.
7. Jagers, P. (1974): Branching Processes with Biological Applications, Wiley.
8. Karlin, S. and Taylor, H.M. (1975): A First Course in Stochastic Processes, Vol. 1, Academic Press.
9. Medhi, J. (1982): Stochastic Processes, Wiley Eastern.
10. Parzen, E. (1962): Stochastic Processes, Holden-Day.

STM – 205 : PROBABILITY **Credits : 3**

Classes of sets, fields, sigma fields, minimal sigma field, Borel sigma field, sequence of sets, lim sup and lim inf of a sequence of sets, measure, probability measure, properties of measure, Caratheodory extension theorem (statement only), Lebesgue and Lebesgue - Steiltzes measures.

Measurable functions, random variables, sequence of random variables, almost sure convergence, convergence in probability (and in measure). Integration of a measurable function with respect to a measure, monotone convergence theorem, Fatou's lemma, dominated convergence theorem.

Borel-Cantelli lemma, independence, weak law and strong law of large numbers for independently and identically distributed sequences.

Convergence in distribution, characteristic function, uniqueness theorem, Levy's continuity theorem (statement only). CLT for a sequence of independent random variables under Lindeberg's condition, CLT for independently and identically distributed random variables.

References :

1. Robert, A. (1972): Real Analysis and Probability, Academic press.
2. Billingsley, P. (1989): Probability and Measure, Wiley.
3. Dudley, R.M. (1989): Real Analysis and Probability, Wadsworth and Books.
4. Kingman, J.F.C. and Taylor, S.J. (1966): Introduction to Measure and Probability, Cambridge University Press.

STM – 206 : Practical paper based on the contents of Papers Survey Sampling(STM – 201) and Statistical Inference – II (STM – 203) **Credits : 2**

STM – 207 : Practical paper based on the contents of Papers Linear Models and Regression Analysis (STM - 202) and Stochastic Processes (STM - 204) **Credits : 2**

STM208M : SAMPLING THEORY, DESIGN OF EXPERIMENTS AND DATA ANALYSIS USING SOFTWARES **Credits : 3**

(The course will involve only the concepts and uses of theories rather than rigorous derivations of the results.)

Basic concepts of sampling from a finite population; sampling versus complete enumeration; simple random sampling; sample size determination; stratified random sampling; systematic sampling; cluster sampling and multi – stage sampling (all sampling schemes without proof of expressions).

Analysis of variance techniques : One way and two way classified data.

Design of experiments : Randomization, replication, local control; completely randomized design; randomized block design and Latin square design; factorial experiments.

Data analysis : The students will be trained to use SPSS and SYSTAT softwares for data analysis. The main focus of the training will also include the use of parametric and non – parametric tests and the interpretation of the results.

References :

1. Cochran, W.G. (1977) : Sampling Techniques, 3rd Edition, Wiley.

2. DesRaj (2000) : Sample Survey Theory, Narosa Publishing House
3. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and Indian Society of Agricultural Statistics.
4. Das, M.N. and Giri, N (1986) : Design and Analysis of Experiments, Springer Verlag.
5. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991) : Fundamentals of Statistics, Vol. II, World Press, Calcutta
6. Gibbons, J.D. (1985) : Non – Parametric Statistical Inference, 2nd Edition, Marcel Dekkar, Inc.
7. Rohatgi, V.K. (1988) : An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
8. Siegel, S. : Non – Parametric Statistics for the Behavioural Sciences,
9. Mood, A.M., Greybill, F.A. and Boes, D.C. (1974) : Introduction to the Theory of Statistics, McGraw Hill

Semester III

STM - 301 : MULTIVARIATE ANALYSIS **Credits : 3**

Multivariate normal distribution and its properties. Random sampling from multivariate normal distribution. Maximum likelihood estimators of parameters, distribution of sample mean vector.

Wishart matrix – its distribution and properties, distribution of sample generalized variance, null and non-null distribution of multiple correlation coefficient.

Hotelling's T^2 and its sampling distribution, application in test on mean vector for one and more multivariate normal population and also on equality of components of a mean vector in multivariate normal population.

Classification problem: Standards of good classification, procedure of classification based on multivariate normal distributions.

Principal components, dimension reduction, canonical variates and canonical correlation—definition, use, estimation and computation.

References :

1. Anderson, T.W. (1983): An Introduction to Multivariate Statistical Analysis, 2nd Ed., Willey.
2. Giri, N.C. (1977): Multivariate Statistical Inference, Academic Press.
3. Kshirsagar, A.M. (1972): Multivariate Analysis, Marcel Dekker.
4. Morrison, D.F. (1976): Multivariate Statistical Methods, 2nd Ed. McGraw Hill.
5. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, J. Wiley.
6. Rao, C.R. (1973): Linear Statistical Inference and its Applications, 2nd Ed. Wiley.
7. Seber, G.A.F. (1984): Multivariate Observations, Wiley.
8. Sharma, S. (1996); Applied Multivariate Techniques, Wiley.
9. Srivastava, M.S. and Khatri, C.G. (1979): An introduction to multivariate statistics, North Holland.
10. Johnson, R. and Wychern (1992): Applied Multivariate Statistical Analysis, Prentice Hall, 3rd Edition.

STM – 302 : DESIGN AND ANALYSIS OF EXPERIMENTS **Credits : 3**

Review of linear estimation and basic designs, missing plot technique:- General theory and applications, Analysis of Co-variance for CRD and RBD.

Incomplete block design: Balanced incomplete block designs, simple lattice designs, Two-associate partially balanced incomplete block designs: association scheme and intra block analysis, group divisible designs.

General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects; study of 2^n and 3^r factorial experiments in randomized blocks; complete and partial confounding, construction of symmetrical confounded factorial experiments, fractional replications for symmetrical factorials, split plot and strip-plot experiments.

Application areas: Response surface experiments; first order designs, and orthogonal designs; clinical trials, treatment-control designs; model variation and use of transformation; Tukey's test for additivity.

References :

1. Alok Dey (1986): Theory of Block Designs, Wiley Eastern.
2. Angela Dean and Daniel Voss (1999): Design and Analysis of Experiment, Springer.
3. Das, M. and Giri, N. (1979): Design and Analysis of Experiments, Wiley Eastern.
4. Joshi, D.D. (1987): Linear Estimation and Design of Experiments, Wiley Eastern.

5. Montgomery, C.D. (1976): Design and Analysis of Experiment, Wiley, New York.
6. Mysers, R.H. (1971): Response Surface Methodology, Allyn and Bacon.
7. Giri (1986): Analysis of Variance, South Asian Publishers.

STM – 303 : RESEARCH METHODOLOGY AND PROJECT WORK – I Credits : 2

(In this paper there will be a theory paper of 70 marks and the rest 30 marks will be assigned to the preparation of project proposal, discussion and its presentation).

Concept and definitions, variables and hypotheses, theory and facts, formulation of research problems, development of research methodology and research methods-collection of data, statistical techniques used, evaluation and accuracy of results, developments of knowledge-approaches, rationalistic mode, scientific mode. Identification of problem, formulation of hypotheses, imagination in the formulation of scientific law, recognition of a problem area and identifying the relative questions.

Steps in research process-

A. Conceptual phase-formulation of the research problem, literature review, developing the hypothesis.

B. Empirical phase- preparing the research design, determination of sample size, collection of data.

C. Analytical phase- analysis of data, hypothesis testing, generalization and interpretations, writing up, conclusions.

Types of variables- independent, dependent and control variables.

Measurements - concept and level of measurement, scaling technique, validity and reliability of a measurement.

Types of data and methods of collection of data, pre-testing, pilot survey, longitudinal survey, prospective and retrospective surveys, sampling and non-sampling errors, sampling unit and sampling frame, population and sample, scrutinizing of data, estimation of coverage and errors in data collection, revisits.

References :

1. Kothari, C.R. (1985): Research Methodology: Methods and Techniques, Wiley Eastern.
2. Dominowski, R.L. (1980): Research Methods, Prentice Hall Inc., New Jersey.
3. Mishra, R.P. (1980): Research Methodology, Handbook Concept Publishing Company, New Delhi.
4. IIPS (1996): Research Methodology, IIPS, Mumbai.

STM – 304 : STATISTICAL DECISION THEORY Credits : 3

Decision problem and 2-person game, utility theory, loss functions, expected loss, decision rules (non-randomized and randomized), decision principles (conditional Bayes, frequentist), inference problems as decision problems, optimal decision rules.

Concept of admissibility and completeness, Bayes rules, admissibility of Bayes rules.

Supporting and separating hyperplane theorems, minimax theorem of for finite parameter s pace, minimax estimators of Normal and Poisson means, admissibility of minimax rules.

Invariant decision rules – location parameter problems, invariance and minimaxity , admissibility of invariant rules, complete class theorem, complete and essentially complete classes in simple estimation and testing situations, estimation of a distribution function.

Sufficient statistics, essentially complete classes of rules based on sufficient statistics, complete sufficient statistics.

Sequential decision rules, Bayes and minimax sequential decision rules, invariant sequential decision problems.

References :

1. Berger, J.O. (1985): Statistical Decision Theory and Bayesian Analysis, 2nd Edition. SpringerVerlag.
2. Ferguson, T.S. (1967): Mathematical Statistics – A Decision Theoretic Approach, Academic Pres.
3. Rohatgi, V.K. (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
4. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
5. Bernando, J.M. and Smith, A.F.M. Bayesian Theory, John Wiley and Sons.
6. Robert, C.P.: The Bayesian Choice: A Decision Theoretic Motivation, Springer.

STM – 305 : ADVANCED OPERATIONS RESEARCH – I **Credits : 3**

Decision Theory: Introduction; decision making under uncertainty; decision making under risk; uses of different criteria.

Decision making in the face of competition.

Two-person games; pure and mixed strategies; existence of solution and uniqueness of value in zero-sum games; finding solution in 2×2, 2×m and m×n games; reduction of game problem to a linear programming problem.

Review of linear programming problems (LPP); revised simplex method; duality theorem; bounded variable problems.

Allocation Problems: transportation problem (TP); degeneracy in TP; unbalanced TP.

Dynamic Programming: Bellman's principle of optimality; general formulation of dynamic programming; computational methods and applications of dynamic programming.

Queuing Models: specifications and effectiveness measures; steady-state solutions of (M/M/I) and (M/M/C) models with associated distributions of queue length and waiting time; M/G/1 queue and Pollazcek – Khinchine result; steady-state solutions of $M/E_K/1$ and $E_K/M/1$ queues; machine interference problem.

Non-Linear Programming: Kuhn-Tucker conditions; Wolfe's and Beale's algorithms for solving quadratic programming problems.

Analytical structure of inventory problems; EOQ formula of Harris; its sensitivity analysis and extensions allowing quantity discounts and shortages; Multi-item inventory subject to constraints.

Inventory models with random demand; the static risk model; P and Q – systems with constant and random lead times.

References:

1. Saaty, T.L. (1961): Elements of Queuing Theory with Applications; McGraw Hill.
2. Gross, D. and Harris, C.M. (1974): Fundamentals of Queuing Theory, John Wiley.
3. Hadley, G. (1964): Non-Linear and Dynamic Programming; Addison Wesley.
4. Taha, H.A. (1982): Operations Research: An Introduction; MacMillan Publishing Company, New York.
5. Kanti Swaroop, Gupta, P.K. and Singh, M.M. (1985): Operations Research, Sultan Chand and Sons.
6. Philips, D.T., Ravindran, A. and Solberg, J.: Operations Research, Principles and Practice.
7. Mckinsey, J.C.C. (1952): Introduction to the Theory of Games; McGraw Hill.
8. Hadley, G. and Whitin, T.M. (1963): Analysis of Inventory Systems; Prentice Hall.

STM – 306 : SURVIVAL ANALYSIS **Credits : 3**

Concept of time, order and random censoring, likelihood in the distributions – exponential, gamma, Weibull, lognormal, Pareto, Linear failure rate, inference for these distribution.

Life tables, failure rate, mean residual life and their elementary classes and their properties.

Estimation of survival function – actuarial estimator, Kaplan – Meier estimator, estimation under the assumption of IFR/DFR, tests of exponentiality against non-parametric classes, total time on test.

Two sample problem – Gehan test, log rank test.

Semi-parametric regression for failure rate – Cox's proportional hazards model with one and several covariates. rank test for the regression coefficient.

Competing risk model, parametric and non-parametric inference for this model.

Multiple decrement life table.

References:

1. Cox, D. R. and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall, New York.
2. Gross A. j. and Clark, V.A. (1975): Survival Distribution: Reliability applications in the Biomedical Sciences, John Wiley and Sons.
3. Elandt – Johnson, R.E. Johnson N. L.: Survival Models and Data Analysis, John Wiley and Sons.
4. Miller, R. G. (1981): Survival Analysis (John Wiley).
5. Kalbfleisch J. D. and Prentice R. (1980): The Statistical Analysis of failure Time data, John Wiley.

STM – 307 : COMPUTER - INTENSIVE STATISTICAL METHODS – I **Credits : 3**

Exploratory data analysis: transforming data, graphical methods of clustering, outliers.

Linear regression**:** Influential observations and diagnostics robust methods, collinearity, variable selection.

Generalized linear models: exponential families and ML estimation, analysis of deviance and variable selection, logistic regression.

Nonlinear regression: estimation, hypothesis testing, goodness of fit.

EM algorithm: applications to missing and incomplete data problems, mixture models.

Smoothing with kernels, density estimation, simple non-parametric regression.

Note on practicals: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages or using high level languages as taught in the core course on Statistical Computing.

References :

1. R. Gnandesikan (1997): Methods for Statistical Data Analysis of Multivariate Observations, Second edition, Wiley.
2. D.A. Belsley, E. Kuh, and R.E. Welsch (1980): Regression Diagnostics, Wiley.
3. P. McCullagh and J.A. Nelder (1999): Generalized Linear Models, Third edition, Chapman and Hall.
4. G.E.F. Seber and C.J. Wild (1989): Nonlinear Regression, Wiley.
5. G.J. McLachlan and T. Krishnan (1997): The EM Algorithms and Extensions, Wiley.
6. J.S. Simonoff (1996): Smoothing Methods in Statistics, Springer.

STM – 308 : TIME SERIES ANALYSIS **Credits : 3**

Time-series as discrete parameter stochastic process, auto covariance and autocorrelation functions and their properties.

Exploratory time Series analysis, tests for trend and seasonality, exponential and moving average smoothing. Holt and Winters smoothing, forecasting based on smoothing.

Detailed study of the stationary processes: (1) moving average (MA), (2) auto regressive (AR), (3) ARMA and (4) AR integrated MA (ARIMA) models. Box-Jenkins models, choice of AR and MA periods.

Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory, estimation of ARIMA model parameters.

Spectral analysis of weakly stationary process, peridogram and correlogram analyses, computations based on Fourier transform.

References:

1. Box, G.E.P. and Jenkins, G.M. (1976): Time series analysis—Forecasting and Control, Holden-day, San Francisco.
2. Anderson, T.W. (1971): The Statistical Analysis of Time Series, Wiley, N.Y.
3. Montgemory, D.C. and Johnson, L.A. (1977): Forecasting and Time Series Analysis, McGraw Hill.
4. Kendall, Sir Maurice and Ord, J.K. (1990): Time Series (Third Edition), Edward Arnold.
5. Brockwell, P.J. and Davis, R.A.: Time Series: Theory and Methods (Second Edition), Springer-Verlag.
6. Fuller, W.A. (1976): Introduction to Statistical Time Series, John Wiley, N.Y.
7. Granger, C.W.J. and Newbold (1984): Forecasting Econometric Time Series, Third Edition, Academic Press.
8. Priestley, M.B. (1981): Spectral Analysis & Time Series, Griffin, London.
9. Kendall, M.G. and Stuart A. (1966): The Advanced Theory of Statistics, Volume 3, Charles Griffin, London.
10. Bloomfield, P. (1976): Fourier Analysis of Time Series—An Introduction, Wiley.
11. Granger, C.W.J. and Hatanka, M. (1964): Spectral Analysis of Economic Time Series, Princeton Univ. Press, N.J.
12. Koopmans, L.H. (1974). The spectral Analysis of Time Series, Academic Press.
13. Nelson, C.R. (1973): Applied Time Series for Managerial Forecasting, Holden-Day.
14. Findley, D.F. (Ed.) (1981): Applied Time Series Analysis II, Academic Press.

Major Elective Papers **Credits : 4**

STM - 309 : Practical paper based on the contents of Papers Multivariate Analysis (STM - 301), Design and Analysis of Experiments (STM – 302) and selected

STM308M : DATA ANALYSIS USING REGRESSION MODELS Credits : 3

(The course will involve a substantial amount of computing and the emphasis will be on applications and interpretations, rather than equations and derivations. Illustrations will be done using R language)

Basics of linear regression with one predictor and multiple predictors, interactions, statistical inference, graphical display of data and fitted models.

Linear regression before and after fitting the model: linear transformations, centering and standardizing, logarithmic and other transformations.

Logistic regression with single predictor, interpreting the regression coefficients, logistic regression with interactions.

Generalized linear model : Poisson regression, logistic – binomial model, regression (normally distributed latent data), ordered and unordered catagorical regression, robust regression.

Simulation of probability models and statistical inferences, simulation for checking model fits.

References :

1. Weisberg, S. (1985) : Applied Linear Regression, 2nd Edition
2. Draper, N.R. and Smith, H. (1998) : Applied Regression Analysis, Wiley
3. Rawlings, John, O. (2001) : Applied Regression Analysis, Springer Verlag.

Semester IV

STM - 401 : BAYESIAN INFERENCE Credits : 3

Subjective probability, its existence and interpretation. Prior distribution, subjective determination of prior distribution. Improper priors, non-informative (default) priors, invariant priors. Conjugate prior families, construction of conjugate families using sufficient statistics of fixed dimension, mixtures of conjugate priors, hierarchical priors and partial exchangeability. Parametric Empirical Bayes.

Bayesian inference : Bayes sufficiency, summary through posterior, predictive inference.

Bayesian decision theory : Bayes solutions for practical decision problems. Point estimation, credible sets, testing of hypotheses. Comparison with classical procedures. Admissibility and minimaxity of Bayes and generalized Bayes procedures.

Ideas on Bayesian robustness. Asymptotic expansion for the posterior density. Bayesian calculation, Monte-Carlo Integration and Markov chain Monte Carlo techniques (without proof).

References:

1. Berger, J.O. : Statistical Decision Theory and Bayesian Analysis, Springer Verlag.
2. Robert, C.P. and Casella, G. : Monte Carlo Statistical Methods, Springer Verlag.
3. Leonard, T. and Hsu, J.S.J. : Bayesian Methods, Cambridge University Press.
4. Bernando, J.M. and Smith, A.F.M. : Bayesian Theory, John Wiley and Sons.
5. Robert, C.P. : The Bayesian Choice: A Decision Theoretic Motivation, Springer.
6. Gemerman, D. : Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference, Chapman Hall.
7. Box, G.P. and Tiao, G.C.: Bayesian Inference in Statistical Analysis, Addison-Wesley.

STM - 402 : NON - PARAMETRIC AND SEMI - PARAMETRIC METHODS Credits : 3

Empirical distribution function, Gilvenko Cantelli Theorem, Kolmogorov Goodness of fit test.

One sample U-statistics, kernel and symmetric kernel, two sample U-statistics, asymptotic distribution of U-statistics. UMVUE property of U-statistics, asymptotic distribution of linear function of order statistics.

Rank tests, locally most powerful rank tests, linear rank statistics and their distributional properties under null hypothesis, Pitman's asymptotic relative efficiency.

One sample location problem, sign test and signed rank test, two sample Kolmogorov Smirnov tests, two simple location and scale problems. Wilcoxon-Mann-Whitney test, normal score test, ARE of various tests based on linear rank statistics. Kruskal-Wallis K sample test.

Cox's proportional hazards model, rank test (partial likelihood) for regression coefficients, Concepts of jackknifing method of Queenouille for reducing bias, Bootstrap methods.

References:

1. Davison, A.C. and Hinkley, D.V. (1997): Bootstrap Methods and Their Application, Cambridge University Press.
2. Gibbons, J.D. (1985): Non-Parametric Statistical Inference, 2nd ed. Marcel Dekker, Inc.
3. Randles, R.H. and Woffe, D.A. (1979): Introduction to the Theory of Non-Parametric Statistics, John Wiley & Sons, Inc.
4. Fraser. D.A.S. (1957): Nonparametric Methods in Statistics, John Wiley & Sons, Inc.
5. Hajek, J. and Sodal. Z. (1967): Theory of Rank Tests, Academic Pess.
6. Puri, M.L. and Sen, P.K. (1971): Nonparametric Methods of Multivariate Analysis, John Wiley & Sons, Inc.
7. Cox, D.R. and Oakes, D. (1983): Survival Analysis, Chapman and Hall.

STM – 403 : APPLIED REGRESSION ANALYSIS **Credits : 3**

Residuals and their analysis, influential observations, power transformations for dependent and independent variables.

Robust and L-1 regression, estimation of prediction error by cross-validation and boot-strap.

Non-linear regression models, different methods of estimation (Least squares, Maximum Likelihood), Asymptotic properties of estimators

Generalized linear models, analysis of binary and grouped data by using logistic models, log-linear models.

Bayes analysis of linear and generalized linear models.

References:

1. Bates, D.M. and Watts, D.G. (1988): Nonlinear Regression, Analysis and its Application, Wiley, New York.
2. Cook, R.D. and Weisberg, S. (1982): Residuals and Inference in Regression, Chapman and Hall, London.
3. Draper, N.R. and Smith, H. (1998): Applied Regression Analysis, 3rd Ed., Willey, New York.
4. Efron, B. and Tibsirani, J.R. (1993): An Introduction to the Bootstrap, Chapman and Hall, New York.
5. Kashirsagar, A.M. (1995): Growth Curves, Marcel and Dekker, New York.
6. McCullagh, P. and Nelder, J.A. (1989): Generalized Linear Models, 2nd Ed., Chapman and Hall, London.
7. Searle, S.R. (1987): Linear Models for Unbalanced Data, Wiley, New York.
8. Seber, G.A. and Wild, G.J. (1989): Nonlinear Regression, Wiley, New York.
9. Robert, C.P.: The Bayesian Choice: A Decision Theoretic Motivation, Springer.

STM – 404 : RELIABILITY THEORY **Credits : 3**

Reliability concepts and measures; components and systems; coherent systems; Reliability of coherent system; cuts and paths; modular decomposition; bounds on system reliability; structural and reliability importance of components.

Life distributions; reliability function; hazard rate; common life distributions – exponential, Weibull, gamma, normal, etc.; Estimation of parameters and tests in these models.

Notions of aging; IFR; IFRA; NBU; DMRL and NBUE classes and their duals; lo of memory property of the exponential distribution; closures of these classes under formation of coherent systems; convolution and mixtures.

Basic ideas of accelerated life testing.

Univariate shock models and life distribution arising out of them; bivariate shock models; common bivariate exponential distributions and their properties.

Maintenance and replacement policies; availability of reparable systems; modelling of a repairable system by a non-homogeneous Poisson process.

Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation.

Reliability growth models; Probability plotting techniques; Hollander – Proschan and Deshpande tests for exponentiality; tests for HPP vs. NHPP with repairable systems.

References:

1. Barlow, R.E. and Proschan, F. (1985): Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.
2. Lawless, J.F. (1982): Statistical Models and Methods of Life Time Data; John Wiley.
3. Nelson, W. (1982): Applied life Data Analysis; John Wiley.
4. Zacks, S.: Reliability Theory; Springer
5. Bain, L. J. and Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.

STM – 405 : ADVANCED OPERATIONS RESEARCH – II **Credits : 3**

Integer Programming: Branch and bound algorithm and cutting plane algorithm. Multi-criterion and goal programming.

Stochastic Programming; quantile rules.

Two-stage programming; use of fractional programming.

Sequencing and scheduling problems: 2 machine n-job and 3–machines n-job problems with identical machine sequence for all jobs; 2-job n-machine problem with different routings; branch and bound method for solving travelling-salesman problem.

Sensitivity analysis. parametric programming.

Project management: CPM and PERT; probability of project completion; PERT-crashing.

Replacement problems: block and age replacement policies; dynamic programming approach for maintenance problems; replacement of items with long life.

Transient solution of M/M/1 queue; bulk queues (bulk arrival and bulk service); finite queues; queues in tandem; GI/G/1 queue and its solution; simulation of queues.

References:

1. Taha, H.A. (1982): Operations Research: An Introduction; MacMillan Publishing Company, New York.
2. Hillier, F.S. and Leiberman, G.J. (1962): Introduction to Operations Research; Holden Day.
3. Kanti Swaroop, Gupta, P.K. and Singh, M. M. (1985): Operations Research; Sultan Chand and Sons.
4. Churchman, C.W.; Ackoff, R.L. and Arnoff, E.L. (1957): Introduction to Operations Research; John Wiley.
5. Mckuisey, J.C.C. (1952): Introduction to the Theory of Games, McGraw Hill.
6. Kleinrock, L. (1975): Queuing Systems, Vol. I; John Wiley.
7. Hadley G. and Whitin, T.M. (1963): Analysis of Inventory Systems; Prentice Hall.
8. Starr, M. K. and Miller, D.W. (1962): Inventory Control – Theory and Practice; Prentice Hall.
9. Shamblin, J.E. and Stevens, G.T. (1974): Operations Research: A Fundamental Approach; McGraw Hill.

STM – 406 : STATISTICAL PROCESSES AND QUALITY CONTROL **Credits : 3**

Basic concepts of process monitoring ad control; process capability and process optimization.

General theory and review of control charts for attribute and variable data; O.C. and A.R.L. of control charts; control by gauging; moving average and exponentially weighted moving average charts; Cu-Sum charts using V-masks and decision intervals; Economic design of X-bar chart.

Acceptance sampling plans for attributes inspection; single and double sampling plans and their properties; plans for inspection by variables for one-sided and two sided specification.

Mil Std. and IS plans; continuous sampling plans of Dodge type and Wald-Wolfiwitz type and then properties.

Sequential sampling plan and its properties; Bayesian sampling plans.

Capability indices Cp, Cpk and Cpm; estimation, confidence intervals and tests of hypotheses relating to capability indices for normally distributed characteristics.

Use of design of experiments in SPC; factorial experiments, fractional factorial designs; construction of such designs and analysis of data.

Multivariate quality control; use of control ellipsoid and of utility functions.

References

1. Montgomery, D.C. (1985): Introduction to Statistical Quality Control; Wiley.
2. Montgomery, D.C. (1985): Design and Analysis of Experiments; Wiley.
3. Ott, E.R. (1975): Process Quality Control; McGraw Hill
4. Phadke, M.S. (1989): Quality Engineering Through Robust Design; Prentice Hall.
5. Wetherill, G.B. (1977): Sampling Inspection and Quality Control; Halsted Press.
6. Wetherill, G.B. and Brown, D.W.: Statistical Process Control: Theory and Practice.

STM – 407 : DEMOGRAPHY **Credits : 3**

Coverage and content errors in demographic data, Chandrasekharan—Deming formula to check completeness of registration data, adjustment of age data- use of Whipple, Myer and UN indices. population transition theory.

Measures of fertility; stochastic models for reproduction, distributions of time of birth, inter-live birth intervals and of number of births (for both homogeneous and homogeneous groups of women), estimation of parameters; estimation of parity progression from open birth interval data.

Measures of Mortality; construction of abridged life tables, infant mortality rate and its adjustments, model life table.

Stable and quasi-stable populations, intrinsic growth rate. Models of population growth and their filling to population data.

Internal migration and its measurement, migration models, concept of international migration.

Methods for population projection, component method of population projection, Nuptiality and its measurements.

References:

1. Kumar, R. (1986): Technical Demography, Wiley Eastern Ltd.
2. Benjamin, B. (1969): Demographic Analysis, George, Allen and Unwin.
3. Chiang, C.L. (1968): Introduction to Stochastic Progression.
4. Cox, P.R. (1970): Demography, Cambridge University Press.
5. Keyfitz, N. (1977): Introduction to the Mathematics of Population-with Revisions, Addison-Wesley, London.
6. Spiegelman, M. (1969): Introduction to Demographic Analysis, Harvard University Press.
7. Wolfenden, H.H. (1954): Population Statistics and Their Compilation, Am Actuarial Society.

STM – 408 : QUANTITATIVE EPIDEMIOLOGY **Credits : 3**

Introduction to modern epidemiology, principles of epidemiologic investigation, surveillance and disease monitoring in populations.

Epidemiologic measures: organizing and presenting epidemiologic data, measure disease frequency, measures of effect association, causation and causal inference.

Design and analysis of epidemiologic studies: types of studies, case-control studies, cohort studies, quantitative methods in screening.

Special Topics: epidemiology of infections and chronic disease, Cancer and cancer prevention, environmental epidemiology.

References:

1. K. J. Rothman and S. Geenland (ed.) (1988). Modern Epidemiology, Lippincott-Raven.
2. S. Selvin (1996). Statistical Analysis of Epidemiologic Data, Oxford University Press.
3. D. McNeil (1996). Epidemiological Research Methods. Wiley and Sons.
4. J. F. Jekel, J. G. Elmore, D.L. Katz (1996). Epidemiology, Biostatistics and Preventive Medicine. WB Saunders Co.

STM – 409 : CLINICAL TRIALS **Credits : 3**

Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I – IV trials, multicenter trials.

Data management: data definitions, case report forms, database design, data collection systems for good clinical practice.

Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of phase III trials with sequential stopping,

Reporting and analysis: analysis of categorical outcomes from Phase I – III trials, analysis of survival data from clinical trials.

Introduction to Meta-analysis of clinical trials.

References:

1. S. Piantadosi (1997): Clinical Trials: A Methodologic Perspective. Wiley and Sons.
2. C. Jennison and B. W. Turnbull (1999): Group Sequential Methods with Applications to Clinical Trials, CRC Press.
3. L. M. Friedman, C. Furburg, D. L. Demets (1998): Fundamentals of Clinical Trials Springer Verlag.
4. J. L. Fleiss (1989): The Design and Analysis of Clinical Experiments. Wiley and Son.
5. E. Marubeni and M. G. Valsecchi (1994): Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.

STM – 410 : COMPUTER - INTENSIVE STATISTICAL METHODS – II **Credits : 3**

Stochastic simulation: generating random variables, simulating standard univariate and multivariate distributions.

Variance reduction: importance sampling for integration, control variates and antithetic variables.

Markov Chain Monte Carlo Methods: Gibbs sampling for standard distributions.

Simulation based testing: simulating test statistics and power functions, permutation tests.

Bootstrap methods: re sampling paradigms, bias and standard errors, confidence intervals, bootstrapping in regression.

Jackknife and cross validation: Jacknife in sample surveys, cross-validation for tuning parameters.

Note on practicals: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages or using high level languages as taught in the core course on Statistical Computing.

References:

1. G.S. Fishman (1996): Monte Carlo: Concepts, Algorithms, and Applications, Springer.
2. R.Y. Rubinstein (1981): Simulation and the Monte Carlo Method, Wiley.
3. M.A. Tanner (1996): Tools for Statistical Interference, Third edition, Springer.
4. B. Efron and R.J. Tibshirani (1993): An introduction to the Bootstrap, Chapman and Hall.
5. J. Shao and D. Tu (1995): Jackknife and the Bootstrap, Springer Verlag.

STM – 411 : COMPUTER PROGRAMMING **Credits : 3**

This course is intended to introduce object-oriented computer programming. It assumes prior exposure to programming in languages in such as C and/or Fortran. The language of choice here is C_{++}.

Introduction to object-oriented programming concepts and design.

Programming in C_{++}: data types and operations, functions and parameters, classes, constructors, input output, control statements such as if-else, switch, for, while and do-while, pointers and references, dynamic allocation, processing of linked lists, arrays and character strings, libraries.

Introduction to program analysis: simple testing and debugging.

Note on practicals/tutorials: As this is programming course, hand-on practical sessions are important and should be held in conjunction with lectures.

References:

1. R. Decker, and S. Hirshfield (1998): The Object Concept: An Introduction to Computer Programming using C_{++}, PWS Publishing.

2. S.B. Lippmann and J. Lajole (1998): C_{++} Primer. Third edition, Addison-Wesley.
3. P. Naughton (1996): The Java Handbook. Tata McGraw-Hill.
4. W.J. Savitch (2001): Problem Solving with C_{++}: The Object of Programming Edition, Addison-Wesley Longman.
5. K. Fukunga (1990): Introduction to Statistical Pattern Recognition, Second Edition, Academic Pres s.
6. G.J. McLachlan (1992): Discriminant Analysis and Statistical Pattern Recognition, Wiley.
7. B.D. Ripley (1996): Pattern Recognition and Neural Networks. Cambridge University Press.

STM – 412 : STATISTICAL PATTERN RECOGNITION **Credits : 3**

Linear classifiers: Linear discriminant function (LDF) for minimum squared error. LDF for binary outputs, perception learning algorithm.

Nearest neighbour decision rules: description, convergence, finite sample considerations, use of branch and bound methods.

Probability of errors: Two classes, normal distributions, equal covariance matrix assumptions, Chernolf bounds and Bhattacharya distance, estimation of probability of error.

Feature selection and extraction: Interclass distance measures, discriminant analysis, probabilistic distance measures, principal components.

Note on practicals: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages or using high level languages as taught in the core course on Statistical Computing.

References:

1. R.O. Duda and P.E. Hart (1973): Pattern Recognition and Scene Analysis, Wiley.
2. K. Fukunga (1990): Introduction to Statistical Pattern Recognition. Second Edition, Academic Press.
3. G.J. McLachlan (1992): Discriminant Analysis and Statistical Pattern Recognition, Wiley.
3. B.D. Ripley (1996): Pattern Recognition and Neural Networks. Cambridge University Press.

STM – 413 : ECONOMETRICS **Credits : 3**

Nature of econometrics, the general linear model (GLM) and its extensions, ordinary least squares (OLS) estimation and prediction, generalized least squares (GLS) estimation and prediction, heteroscedastic disturbances, pure and mixed estimation.

Auto correlation, its consequences and tests. Theil BLUS procedure, estimation and prediction, multicollinearity problem, its implications and tools for handling the problem, ridge regression.

Linear regression and stochastic regression, instrumental variable estimation. errors in variables, autoregressive linear regression, lagged variables, distributed lag models, estimation of lags by OLS method, Koyck's geometric lag model.

Simultaneous linear equations model and its generalization, identification problem, restrictions on structural parameters, rank and order conditions.

Estimation in simultaneous equations model, recursive systems, 2 SLS estimators, limited information estimators, k-class estimators. 3 SLS estimator, full information maximum likelihood method, prediction and simultaneous confidence intervals.

References :

1. Apte, P.G. (1990): Text books of Econometrics, Tata McGraw Hill.
2. Cramer, J.S. (1971): Empirical Econometrics, North Holland.
3. Gujarathi, D. (1979): Basic Econometrics, McGraw Hill.
4. Intrulligator, M.D. (1980): Econometric models—Techniques and applications, Prentice Hall of India.
5. Johnston, J. (1984): Econometric methods. Third edition, McGraw Hill.
6. Klein, L.R. (1962): An introduction to Econometrics, Prentice Hall of India.
7. Koutsoyiannis, A. (1979): Theory of Econometrics, Macmillan Press.
8. Malinvaud, E. (1966): Statistical methods of Econometrics, North Holland.
9. Srivastava, V.K. and Giles D.A.E. (1987): Seemingly unrelated regression equations models, Maicel Dekker.
10. Theil, H. (1982): Introduction to the theory and practice of Econometrics, John Wiley.
11. Walters, A. (1970): An introduction to Econometrics, Macmillan & Co.
12. Wetherill, G.B. (1986): Regression analysis with applications, Chapman Hall.

STM – 414 : ACTUARIAL STATISTICS **Credits : 3**

Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.

Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications.

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions.

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities.

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits.

A brief outline of payment premiums and net premiums

References:

1. N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt (1966), 'Actuarial Mathematics,' Society of Actuarials, Ithaca, Illinois, U.S.A., Second Edition (1997).
2. Spurgeon, E.T. (1972): Life Contingencies, Cambridge University Press.
3. Neill, A. (1977): Life Contingencies, Heinemann.

STM – 415 : OFFICIAL STATISTICS **Credits : 3**

Introduction to Indian and International statistical systems. role, function and activities of central and state statistical organizations, organization of large scale sample surveys, role of national sample survey organization general and special data dissemination systems.

Population growth in developed and developing countries, evaluation and performance of family welfare programmes, projections of labour force and manpower, scope and content of population census of India.

System of collection of agricultural statistics, crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects.

Statistics related to industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.

References:

1. Basic Statistics Relating to the Indian Economy (CSO), 1990.
2. Guide to Official Statistics (CSO) 1999.
3. Statistical System in India (CSO), 1995.
4. Principles and accommodation of National Population Censuses, UNESCO.
5. Panse, V.G.: Estimation of Crop Yields (FAO).
6. Family Welfare Yearbook, Annual Publication of D/o Family Welfare.
7. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.

STM–416 : Practical paper based on the contents of selected Elective Papers **Credits : 3**

STM–417 : Project Work - II **Credits : 2**

The Project Work – II will be spread over the whole semester. A project may be undertaken by a group of students. However, the project report shall be submitted by each member of the group separately. A project report shall clearly state the problem addressed, the methodology adopted, the assumptions and the hypotheses formulated, any previous reference to the study undertaken, statistical analyses performed and the broad conclusion drawn. There shall be an external examiner and an internal examiner (preferably the supervisor of the student) for the evaluation of the project work. Out of total 100 marks assigned to the project, 60 marks will be assigned on the evaluation of the project work separately by both the examiners and 40 marks will be assigned jointly by the examiners on the oral presentation and viva – voce).

M.Sc. ZOOLOGY
Department of Zoology
Banaras Hindu University

Semesterwise distribution of Courses and Credits

Semester-I		
Course Code	**Title**	**Credits**
ZOM101	Non Chordata & Chordata (Credits 1.5+1.5)	3
ZOM102	Entomology & Fish Biology (Credits 1.5+1.5)	3
ZOM103	Vertebrate Endocrinology	4
ZOM104	Analytical and Molecular Techniques & Microscopy (Credits 3+1)	4
ZOM105	*Lab. exercises based on courses ZOM101 & ZOM102*	3
ZOM106	*Lab. exercises based on courses ZOM103 & ZOM104*	3
ZOM107M #	*Minor Elective:* Evolutionary Biology *(for students of other PG programmes)* *Minor Elective (for Zoology students)*	3
	Total	**23**
Semester-II		
ZOM201	Cytogenetics & Genetics (Credits 2+2)	4
ZOM202	Biochemistry & Cell Structure and Function (Credits 2+2)	4
ZOM203	Histology and Histochemistry & Bioinformatics (Credits 1.5 + 1.5)	3
ZOM204	Mammalian Physiology & Neurobiology (Credits 2.5+1.5)	4
ZOM205	*Lab. exercises based on course ZOM201*	2
ZOM206	*Lab. exercises based on course ZOM202*	2
ZOM207	*Lab. exercises based on courses ZOM203 & ZOM204*	3
ZOM208M #	*Minor Elective:* Hormones and Diseases *(for students of other PG programmes)* *Minor Elective (for Zoology students)*	3
	Total	**25**
Semester-III		
ZOM301	Developmental Biology & Immunology (Credits 2+1)	3
ZOM302(A-E)	Major Elective Course I	3
ZOM303(A-E)	Major Elective Course II	3
ZOM304(A-E)	Major Elective Course III	3
ZOM305	*Lab. exercises based on course ZOM301*	2
ZOM306(A-E)	*Lab. exercises based on courses ZOM302,303 & 304(A-E)*	3
#	*Minor Elective (for Zoology students)*	3
	Total	**20**
Semester-IV		
ZOM401	Animal Behaviour & Environmental Biology (Credits 1.5+1.5)	3
ZOM402	Evolution & Parasitology (Credits 2+1)	3
ZOM403(A-E)	Major Elective Course IV	3
ZOM404(A-E)	Major Elective Course V	3
ZOM405	*Lab. exercises based on courses ZOM401 & ZOM402*	3
ZOM406(A-E)	*Lab. exercises based on courses ZOM403 & 404 (A-E)*	2
ZOM407(A-E)	*Project work/ Dissertation*	4
ZOM408	*Seminar*	1
	Total	**22**
	Grand Total	**90**

M.Sc. Zoology students will opt 3 Minor Electives (3 credit each in semester I, II & III) offered by other PG Programmes of Faculty.

Note: 1. Each student will opt *one out of the five* Major Elective Groups (A-E). Each group will have a set of *five* theory courses and corresponding laboratory exercises, which will be spread over Semester III & IV. The *Project work/ Dissertation* will be carried out in the field of the respective Group (A-E).

2. Group-wise distribution of Major Elective courses are given on next page.

SEMESTER I

ZOM 101: NON CHORDATA & CHORDATA
(Credit 3)

Section A: Non Chordata (Credit 1.5)	**Hours of teaching**
1. Protozoa 1.1 Nucleus and reproduction 1.2 Colonial protozoans and theories of the origin of metazoans	**3**
2. Porifera: canal system	**2**
3. Cnidaria 3.1 Nematocysts 3.2 Polymorphism in Siphonophora	**2**
4. Annelida 4.1 Adaptive radiation in polychaetes 4.2 Trochophore larva: structure and significance	**3**
5. Mollusca 5.1 Nervous system 5.2 Modifications of foot	**3**
6. Arthropoda 6.1 Affinities of trilobites 6.2 Crustacean larvae and their significance	**3**
7. Echinodermata: larval forms and their significance	**1**
8. Salient features and affinities of 8.1 Placozoa 8.2 Mesozoa 8.3 Rotifera 8.4 Phoronida 8.5 Sipuncula	**3**

Section B: Chordata (Credit 1.5)	**Hours of teaching**
1. Characteristic features and affinities of the following 1.1 Protochordata 1.1.1 Hemichordata 1.1.2 Urochordata 1.1.3 Cephalochordata 1.2 Cyclostomes	**4**
2. Transition from agnatha to gnathostomata	**1**
3. Origin of the following 3.1 Fish 3.2 Amphibia 3.3 Reptile 3.4 Bird 3.5 Mammal	**5**
4. Adaptive radiation in vertebrates 4.1 Aquatic 4.2 Terrestrial 4.3 Aerial 4.4 Arboreal 4.5 Fossorial	**5**
5. Parental care in amphibians	**1**
6. Skull in reptiles	**1**
7. Venom in ophidians	**1**
8. Flightless birds	**1**

9. Modification of beak, feet and palate in birds **1**

Books Recommended

1. Barnes: Invertebrate Zoology (4th ed 1980, Holt-Saunders International)
2. Barnes: The Invertebrates – A synthesis (3rd ed 2001, Blackwell)
3. Hunter: Life of Invertebrates (1979, Collier Macmillan)
4. Marshall: Parker & Haswell Text Book of Zoology, Vol. I (7th ed 1972, Macmillan)
5. Moore: An Introduction to the Invertebrates (2001, Cambridge University Press)
6. Harvey et al: The Vertebrate Life (2006)
7. Colbert et al: Colbert's Evolution of the Vertebrates: A history of the backboned animals through time (5th ed 2002, Wiley - Liss)
8. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
9. Jordan and Verma: Chordate Zoology (1998, S. Chand)
10. Kotpal: The Birds (4th ed 1999, Rastogi Publications)
11. McFarland et al: Vertebrate Life(1979, Macmillan Publishing)
12. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
13. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
14. Sinha, Adhikari and Ganguli: Biology of Animals, Vol. II (1988, New Central Book Agency)
15. Young: The life of vertebrates (3rd ed 2006, ELBS/Oxford)

ZOM 102: ENTOMOLOGY & FISH BIOLOGY (Credit 3)

Section A: Entomology (Credit 1.5) **Hours of teaching**

1. Importance and taxonomic richness of insects **1**

2. External anatomy **4**
- 2.1 Segmentation and tagmosis
- 2.2 Integument: structure and functions of cuticle, sclerotization and colouration
- 2.3 Head: types of head and antennae
- 2.4 Thorax: legs and wings

3. Internal anatomy and physiology **9**
- 3.1 Nervous system
- 3.2 Endocrine system and function of hormones
- 3.3 Circulatory system: heart and haemolymph
- 3.4 Respiratory system
  - 3.4.1 Aerial respiration: spiracles, trachea and tracheoles
  - 3.4.2 Aquatic respiration
- 3.5 Digestive system
  - 3.5.1 Structure of gut
  - 3.5.2 Digestion and absorption of food
- 3.6 Excretory system and waste disposal
  - 3.6.1 Malpighian tubules
  - 3.6.2 Nitrogen excretion
- 3.7 Reproduction
  - 3.7.1 Female and male systems
  - 3.7.2 Physiology of reproduction

4. Sensory system **1**
- 4.1 Tactile mechanoreceptor and position receptor
- 4.2 Compound eye

5. Applied Entomology **5**
- 5.1 Insects as friends and foes
- 5.2 Insect plant-interaction
- 5.3 General methods of insect pest management
- 5.4 Medical entomology: insects as vectors of diseases and their control

Section B: Fish Biology (Credit 1.5) **Hours of teaching**

1. Major groups of living fishes	**1**
2. Nutritional value and economic importance of fishes	**1**
3. Fins: origin, types and function	**3**
4. Respiratory organs	**3**
4.1 Water breathing	
4.2 Air-breathing	
5. Swim bladder	**2**
6. Electric organs	**2**
7. Poisonous and venomous fishes	**2**
8. Fish migration	**2**
9. Fisheries	
9.1 Definition and classification	**1**
9.2 Outlines of fish culture in ponds	**2**
10. Ichthyology and its scope	**1**

Books Recommended

Entomology

1. Atwal: Agricultural Pests of India and South East Asia (1986, Kalyani Publishers)
2. Chapman: The Insects: structure and function (4th ed, 1998, ELBS)
3. Gilbert et al: Comprehensive Molecular Insect Science Volume 1- 7 (2005, Elsevier)
4. Hill: Pest of stored foodstuffs and their control (2002, Springer)
5. Imms: A general text book of entomology, 2 vols (1997, Asia Publishing House)
6. Klowden: Physiological Systems in Insects (2002, Academic Press)
7. McGavin: Essential Entomology (2001, Oxford Univ Press)
8. Mullen and Durden: Medical and Veterinary Entomology (2002, Academic Press)
9. Resh and Carde: Encyclopedia of Insects (2003, Academic Press)
10. Srivastava: A text book of applied entomology, Vol I & II (1993, Kalyani Publishers)
11. Wigglesworth: Principles of Insect Physiology (1972, ELBS)

Fish Biology

1. Brown: Physiology of fishes, Vols 1 and 2 (1957, Academic press)
2. Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, S. Chand)
3. Hoar and Randall: Fish Physiology, Volumes I-XV (1969-onwards, Academic Press)
4. Khanna and Singh: A textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
5. Lagler, Bardach, Miller and May Passino: Ichthyology (2003, Wiley)
6. Mishra: Records of Indian Museum an aid to the identification of the common commercial fishes of India and Pakistan, Vol. 5 (Part I-IV) (1962)
7. Norman and Greenwood: A History of Fishes (3rd ed 1975, Ernest Bvenn Limited)
8. Pillay: Aquaculture: Principles and Practices Fishing News Books (2005, First Indian reprint)
9. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)
10. Srivastava: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan)
11. Parihar: Fish Biology and Indian fisheries (1999, Central publishing House Allahabad)
12. Singh: Advances in Fish Research, Vol. I, II and III (Fisheries and Fish Biology: Ed Datta Munshi) (1993, 1997and 2004, Narendra Publishing House Delhi)

ZOM 103: VERTEBRATE ENDOCRINOLOGY
(Credit 4)

Section A: Comparative Endocrinology (Credit 2) **Hours of teaching**

1. Vertebrate endocrine system	**1**
2. Hypothalamo-hypophysial system	**7**
2.1 Neurosecretion	
2.2 Hypothalamic neurosecretory centers	
2.3 Neurohypophysis	

2.3.1 General organization
2.3.2 Median eminence: structure and function
2.3.3 Octapeptide hormones

2.4. Adenohypophysis
2.4.1 General organization
2.4.2 Distribution of pituitary cell types and functions (teleost model)

3. Urophysis: structure and function **2**

4. Pineal organ: structure and function **2**

5. Comparative anatomy of thyroid gland and its role in metamorphosis (amphibian model) **3**

6. Comparative anatomy of adrenocortical and medullary homologues **2**

7. Gonads **5**
7.1 Structure of testis and ovary
7.2 Steroidogenic sites
7.3 Steroid hormones and their functions

8. Endocrine control of colour change with emphasis on pars intermedia function in amphibians **2**

9. Endocrine control of osmoregulation in fish **2**

Section B: Mammalian Endocrinology ***(Credit 2)***

Hours of teaching

1. Mechanism of hormone action **3**
1.1 Protein hormones
1.1.1 Membrane receptors
1.1.2 G-proteins
1.1.3 Cyclic AMP signaling cascade
1.1.4 PKC signaling pathway
1.2 Steroid hormones (genomic and nongenomic pathways)

2. Hypothalamo-hypophysial System **8**
2.1 General organization
2.2 Neurohypophysial octapeptides (oxytocin and vasopressin)
2.3 Hypophysiotropic hormones: chemistry, localization and actions
2.4 Adenohypophysial hormones: chemistry and physiological roles of
2.4.1 Somatotropin and prolactin
2.4.2 Glycoprotein hormones (FSH, LH and TSH)
2.4.3 Pro-opiomelanocortin (ACTH, MSH, □-LPH and □-endorphin)
2.5 Neural control of adenohypophysis

3. Thyroid hormones: biosynthesis, control of secretion and physiological roles **2**

4. Steroid hormones: biosynthetic pathways **1**

5. Testis: organization and physiological roles of androgens **2**

6. Ovary: organization and physiological roles of estrogen, progesterone,relaxin and inhibin **3**

7 Adrenal cortex **2**
7.1 Organization
7.2 Control of mineralocorticoid and glucocorticoid hormones
7.3 Physiological role of glucocorticoids and mineralocorticoids

8. Adrenal medulla: catecholamine biosynthesis, release and physiological role **1**

9 Role of parathormone, calcitonin and vitamin D in calcium homeostasis **1**

10. Endocrine pancreas: biosynthesis and physiological actions of insulin and glucagon **2**

11. Gastrointestinal hormones (secretin, gastrin and cholecystokinin) **1**

Books Recommended

1. Bentley: Comparative Vertebrate Endocrinology (1998, Cambridge University Press)
2. Chester-Jones et al: Fundamentals of Comparative Endocrinology (1987, Plenum Press)
3. Gorbman et al: Comparative Endocrinology (1983, John Wiley)
4. Norris: Vertebrate Endocrinology (4th ed 2007, Elsevier)

5. Schreibman & Pang: Vertebrate Endocrinology Vol I-IV, Fundamentals & Biomedical Implications (1985 & onwards, Academic Press)
6. Hadley: Endocrinology, Prentice Hall (2000, International Edition)
7. Brooks and Marshall: Essentials of Endocrinology (1995, Blackwell Science)
8. Turner and Bagnara: General Endocrinology (1984, Saunders)
9. Larson: Williams Textbook of Endocrinology (10th ed 2002, Saunders)

ZOM 104: ANALYTICAL AND MOLECULAR TECHNIQUES & MICROSCOPY

(Credit 4)

Section A: Analytical and Molecular Techniques **(Credit 3)**

	Hours of teaching
1. Buffers	**2**
1.1 pH and its determination	
1.2 Preparation of buffer	
2. Centrifugation	**3**
2.1 Basic principles	
2.2 Types of rotors	
2.3 Clinical, high speed and ultracentrifuge	
3. Spectrophotometry	**2**
3.1 Types of spectrophotometer	
3.2 Beer-Lambert's law, molar extinction coefficient	
3.3 Absorption spectrum	
3.4 Principles of UV- Vis spectrophotometry	
4. Electrophoresis	**4**
4.1 Principles	
4.2 Agarose- and polyacrylamide gel	
4.3 Isoelectrofocussing	
4.4 Two-dimensional	
5. Chromatography	**6**
5.1 Principles	
5.2 Paper and thin layer chromatography	
5.3 Column chromatography	
5.3.1 Gel filtration	
5.3.2 Ion exchange	
5.3.3 Affinity	
5.4 Introduction to FPLC and HPLC	
5.5 Introduction to mass spectrometry: MALDI-TOF	
6. Introduction to NMR and X-ray crystallography	**2**
7. Radio-tracer techniques	**4**
7.1 Unit of radioactivity and half-life	
7.2 Measurement of radioactivity (and emission)	
7.3 Applications of radioisotopes	
7.4 Safety measures	
8. Detection of proteins	**2**
8.1 Western blotting	
8.2 ELISA	
9. DNA-protein and protein-protein interactions	**6**
9.1 South-Western	
9.2 DNA foot printing	
9.3 EMSA	
9.4 Yeast two-hybrid	
9.5 Phage display	
9.6 Far Western	
10. Recombinant DNA techniques	**6**
10.1 Restriction enzymes	
10.2 Cloning vectors	

10.3 Preparation and screening of cDNA and genomic DNA libraries
10.4 Southern and Northern hybridizations
10.5 *In situ* hybridization
10.6 Polymerase chain reaction: principles and applications

11. Introduction to DNA sequencing **2**

Books Recommended

1. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd ed 1993, Benjamin/Cumin)
2. Freifelder: Physical Biochemistry (2nd ed 1982, Freeman)
3. Holme and Peck: Analytical Biochemistry (3rd ed 1998, Tata McGraw Hill)
4. Plummer: An Introduction to Practical Biochemistry (3rd ed 1990, Tata-McGraw Hill)
5. Switzer and Garrity: Experimental Biochemistry (92nd ed 1999, Freeman)
6. Wilson and Walker: Principles of Biochemical and Molecular Biological Techniques (6^{th} ed 2006, Cambridge Univ Press)

Section B: Microscopy **(Credit 1)**
Hours of teaching

1. Basic principles of microscopy **2**

2. Types of microscopes and their biological applications **10**
2.1 Bright-field microscope: numerical aperture, limit of resolution, types of objectives, ocular and stage micrometers
2.2 Dark-field microscope
2.3 Phase-contrast microscope
2.4 Differential interference contrast microscope
2.5 Fluorescence microscope
2.6 Confocal microscope
2.7 Atomic force microscopy
2.8 Transmission and scanning electron microscopes

3. Photomicrography and image processing **1**

Books recommended

1. Alberts et al: Molecular Biology of the Cell (2002, Garland)
2. Karp: Cell and Molecular Biology (2007, Wiley)
3. Lodish et al: Molecular Cell Biology (2007, Freeman)
4. Pollard & Earnshaw: Cell Biology (2002, Saunders)
5. Ruthman: Methods in Cell Research (1970, Bell & Sons)

LABORATRORY EXERCISES

ZOM 105: NONCHORDATA & CHORDATA AND ENTOMOLOGY & FISH BIOLOGY
(Credit 3)

Part A: Non Chordata & Chordata (Credit 1.5)

Non Chordata

1. Preparation of permanent slides
   1.1 Protozoa: *Paramecium* (whole mount) and demonstration of food vacuoles
   1.2 Cnidaria: *Bougainvillea, Sertularia*
   1.3 Arthropoda: *Cyclops*, Megalopa/Zoea, booklung of scorpion
   1.4 Mollusca: glochidium larva
   1.5 Echinodermata: pedicellaria, tubefeet
2. Dissections

2.1 Arthropoda: reproductive system of *Palamnaeus*
2.2 Mollusca: nervous system of *Mytilus* and *Aplysia/Sepia*

3. Study of museum specimens
   3.1 Porifera
   3.2 Cnidaria
   3.3 Annelida
   3.4 Arthropoda
   3.5 Mollusca
   3.6 Echinodermata

Chordata

1. Study of external features of *Branchiostoma* and permanent preparation of its oral hood, velum and pharyngeal wall
2. Study of whole mount preparations of following proto-chordates
   2.1 *Doliolum, Pyrosoma, Salpa* and *Oikopleura*
   2.2 T.S. through pharynx, gonad and post anal region of *Branchiostoma*
   2.3 T.S. and L.S. through proboscis of *Balanoglossus*
3. Permanent preparation of test and spicules of *Herdmania*
4. Dissections of air-sacs and urino-genital systems of pigeon
5. Study of museum specimens
   5.1 Amphibia
   5.2 Reptiles
   5.3 Birds
   5.4 Mammals

Part B: ENTOMOLOGY & FISH BIOLOGY
(Credit 1.5)

Entomology

1. Study of external morphology of cockroach

2. Internal anatomy of cockroach
   2.1 Alimentary canal
   2.2 Salivary apparatus: dissection and *in toto* stained preparation
   2.3 Permanent mounting of heart
3. Dissection of frontal ganglion, brain, corpora cardiaca, corpora allata and recurrent nerve
4. Dissection and mounting of prothoracic gland
5. Dissection of male and female reproductive systems of cockroach
6. Study of external morphology of honey bee and dissection of sting apparatus
7. Study of following using permanent slides/specimens: L. S. of teleotrophic and polytrophic ovarioles, T. S. of testis, and brain showing MNSC, whole mount of head of louse, CC & CA and chironomous larva

Fish Biology

1. Classification of the following locally available fishes using key
   1.1 Carps: *Catla catla; Labeo rohita, Cirrhina mrigala*
   1.2 Catfishes: *Heteropneustes fossilis, Clarias batrachus*
2. Dissection and display of accessory respiratory organs of
   2.1 *Clarias batrachus*
   2.2 *Channa sp*
   2.3 *Heteropneustes fossilis*
3. Dissection of carp showing interrelationship between the gas (swim or air) bladder and Weberian ossicles
4. Mounting of respiratory epithelium of accessory respiratory organs of *H. fossilis* and air bladder epithelium of carp

5. Study of museum specimens of fishes having electric organs, venomous organs and air breathing organs
6. Study of T.S. of gills, accessory respiratory organs and swim bladder from prepared slides
7. Visit to a local pond or fishing site

ZOM 106: VERTEBRATE ENDOCRINOLOGY AND ANALYTICAL AND MOLECULAR TECHNIQUES & MICROSCOPY

Part A: Vertebrate Endocrinology
(Credit 1.5)

1. Handling and maintenance of rat in laboratory
2. Survey of endocrine glands and reproductive organs in *Calotes* and rat
3. Surgical ablations of testis, ovary, adrenal and thyroid in *Calotes* and rat
4. Study of oestrous cycle of rat by vaginal smear preparation
5. Study of the following using permanent slides
   5.1 Endocrine glands and reproductive organs of rat
   5.2 Gonads (testis and ovary from fish to birds)
   5.3 Thyroid of fish (pharyngeal and ectopic) and reptile
   5.4 Adrenal homologues (interrenal and chromaffin tissues) in fish and reptile
   5.5 Cell types of fish pituitary
   5.6 Hypothalamo-neurohypophsial system of a catfish in *in situ* preparation
6. Immuocytochemical identification of pituitary cell types in fish and amphibians using permanent slides
7. Demonstration of ELISA-based hormone assay

Part B: Analytical and Molecular Techniques & Microscopy
(Credit 1.5)

Analytical and Molecular Techniques **(Credit 1)**

1. Preparation of buffer and measurement of pH using pH meter
2. Demonstration of separation of subcellular organelles by differential centrifugation
3. Verification of Beer's law and preparation of absorption spectrum of riboflavin
4. Demonstration of separation of protein by native and SDS-polyacrylamide gel electrophoresis
5. Separation of amino acids by paper chromatography
6. Demonstration of separation of blue dextran and riboflavin by gel filtration column chromatography
7. Demonstration of tracer techniques
8. Isolation of plasmid, restriction digestion and determination of size by agarose gel electrophoresis
9. Demonstration of DNA amplification by polymerase chain reaction

Microscopy
(Credit 0.5)

1. Study of different components of student's microscope and its assembly
2. Study of different components of stereobinocular microscope and its assembly
3. Study of different parts of binocular research microscope
4. Measurement of microscopic object using ocular and stage micrometers
5. Setting up of darkfield and phase contrast microscope
6. Demonstration of working of fluorescence, confocal and electron microscopes

MINOR ELECTIVE

(To be offered to students of other department in the Faculty)

ZOM107M: EVOLUTIONARY BIOLOGY

	Hours of teaching
1. Evolutionary time scale and geological eras	**2**
2. Origin and early history of life 2.1 Theories about the origin of life 2.2 Theories about the origin of cell	
3. Organic evolution: concept and evidences (comparative anatomy, embryology, biogeography, palaeontology, genetics, biochemistry and physiology)	**4**
4. Theories of evolution: Lamarckism, Darwinism and Modern theories	**4**
5. Population as unit of evolution 5.1 Gene frequencies in Mendelian population 5.2 Hardy-Weinberg Equilibrium 5.3 Major evolutionary forces	**4**
6. Species and phylogenetic relationships 6.1 Concepts of species 6.2 Modes of speciation 6.3 Phylogenetic relationships	**4**
7. Evolution at molecular level 7.1 Genomic and proteomic changes 7.2 Molecular clock 7.3 Molecular phylogeny	**4**
8. Evolution of man 8.1 Hominid evolution: anatomical, geographical and cultural 8.2 Ancestry of *Homo sapiens*: molecular phylogenetic relationship 8.3 Peopling of continents	**4**
9. Environmental contexts of evolutionary changes 9.1 Environment and global climate patterns 9.2 Responses to environmental variation 9.3 History of biodiversity and extinction 9.4 Adaptation to specific habitats with examples	**3**
10. Evolution of behaviour 10.1 Behaviour as phenotypic traits 10.2 Adaptive value of behaviour 10.3 Role of behaviour in evolution 10.4 Interactions among species (competition, predation, parasitism, mutualism and mimicry)	**4**
11. Evolution of reproductive mechanisms: asexual and sexual reproduction; evolution of cleidoic egg	**2**
12. Biochemical evolution: metabolic pattern changes (autotrophic, heterotrophic, anaerobic and aerobic)	**2**

Books Recommended

1. Coyne and Orr: Speciation(2004, Sinauer)
2. Dobzhansky et al: 1976 Evolution (2004, Surjeet Publ)
3. Dodson: Evolution: Process and Product (1964, Reinhold Publishing Corp)
4. Freeman and Herron: Evolutionary Analysis (1998, Prentice Hall)
5. Futuyma: Evolutionary Biology(1998, Sinauer)
6. Hartl and Clarke: Principles of Population Genetics (1989 & 1997, Sinauer)
7. Hochachha and Samero: Biochemical Adaptations(1984, Princeton University Press edition)
8. Jobling et al: Human Evolutionary Genetics: Origins, Peoples & Diseases (2004, Garland Science)
9. Kimura: The Neutral Theory of Molecular Evolution (1990, Cambridge)
10. Koonin and Galperin: Sequence-evolution-Function: Computational Approaches in comparative Genomics (Kluwer Academic Publishers)
11. Hsiung and Graur: Fundamentals of Molecular Evolution (1991, Sinauer)

12. Mader: Biology (2007, McGraw)
13. Mayr: Populations, Species and Evolution: An Abridgement of Animal Species and Evolution (1971, Belknap Press)
14. Moody (1978): Introduction to Evolution. Kalyani Publ.
15. Prosser (1986): Adaptational Biology: Molecules to organism . John Wiley
16. Purves et al. (2004): Life: The Science of Biology. Sinauer
17. Raven and Johnson (2002): Biology. Mc Graw Hill
18. Ridley (1993): Evolution. Blackwell.
19. Savage (1963): Evolution. Holt, Rinehart and Winston
20. Stearns (1999): The Evolution of Life Histories. Oxford.
21. Stebbins (1979): Processes of Organic Evolution. Prentice- Hall of India
22. Strickberger (2000): Evolution. Jones and Bartlett.
23. White (1978): Modes of Speciation. Freeman

SEMESTER II

ZOM 201: CYTOGENETICS & GENETICS

(Credit 4)

Section A: Cytogenetics (Credit 2)

Hours of teaching

1. Eukaryotic chromatin structure and chromsome organization **9**

1.1 Classes of DNA
1.2 Chromosomal proteins: histones and their modifications, non-histone proteins, scaffold/matrix proteins
1.3 Levels of chromatin condensation at interphase and metaphase stages
1.4 Nuclear matrix and organization of interphase nucleus
1.5 Centromere, kinetochore and telomere
1.6 Metaphase chromosome banding
1.7 Chromosome and chromatid type aberrations

2. Giant chromosomes: models for studies on chromosome organization and gene expression **4**

3. Cell division **7**

3.1 Mitosis
3.1.1 Role of maturation promoting factor
3.1.2 Chromosomal movement
3.1.3 Exit from mitosis
3.1.4 Cytokinesis
3.2 Meiosis
3.2.1 Chromosome pairing and recombination
3.2.2 Genetic regulation of meiosis

4. Human cytogenetics **6**

4.1 Karyotype and nomenclature of metaphase chromosome bands
4.2 Chromosome anomalies and disease
4.3 Types of chromosomal anomalies
4.4 Common syndromes caused by aneuploidy, mosaicism, deletion and duplication
4.5 Chromosomal anomalies in malignancy (chronic myeloid leukemia, Burkitt lymphoma, retinoblastoma and Wilms' tumour)
4.6 Fragile site and X-linked mental retardation

Section B: Genetics (Credit 2)

Hours of teaching

1. Mendel's laws and their chromosomal basis **1**

2. Extensions of Mendelism **1**

2.1 Dominance relationships
2.2 Epistasis
2.3 Pleiotropy

2.4 Expressivity and penetrance

3. Methods of gene mapping **6**

3.1 3-point test cross in *Drosophila*
3.2 Gene mapping in human by linkage analysis in pedigrees
3.3 Tetrad analysis in *Neurospora*
3.4 Gene mapping in bacteria by conjugation, transformation and transduction

4. Gene mutation and DNA repair **6**

4.1 Types of gene mutations
4.2 Methods for detection of induced mutations
4.3 P-element insertional mutagenesis in *Drosophila*
4.4 DNA damage and repair

5. Nature of the gene and its functions **6**

5.1 Evolution of the concept of gene
5.2 Fine structure of gene (*rII* locus)
5.3 Regulation of gene activity in *lac* and *trp* operons of *E.coli*
5.4 Introduction to gene regulation in eukaryotes
5.4.1 Organization of a typical eukaryotic gene
5.4.2 Transcription factors, enhancers and silencers
5.4.3 Transcriptional and post-transcriptional regulation
5.4.4 Noncoding genes

6. Organization and function of mitochondrial DNA **1**

7. Quantitative inheritance **2**

8. Applications and implications of genetic engineering **3**

8.1 Genetic manipulations in plants and animals
8.2 Detection of genetic disorders
8.3 Gene therapy

***Books Recommended*:**

1. Alberts et al: Essential Cell Biology (1998, Garland)
2. Alberts et al: Molecular Biology of the Cell (2002, Garland)
3. Bostock & Sumner: Eukaryotic Chromosome (1987, North-Holland)
4. Brooker: Genetics : Analysis and Principles (1999, Addison-Wesley)
5. DeRobertis & DeRobertis: Cell and Molecular Biology (1987, Lee & Febiger)
6. Gardner et al: Principles of Genetics (1991, John Wiley)
7. Griffith et al: Modern Genetic Analysis (2002, Freeman)
8. Hartl & Jones: Essential Genetics: A Genomic Perspective (2002, Jones & Bartlet)
9. Karp: Cell and Molecular Biology (2002, John Wiley & Sons)
10. Lewin, Genes VIII (2004, Wiley)
11. Lodish et al: Molecular Cell Biology (2000, Freeman)
12. Pollard & Earnshaw: Cell Biology (2002, Saunders)
13. Russell: Genetics (2002, Benjamin Cummings)
14. Snustad & Simmons: Principles of Genetics (2003, John Wiley)

ZOM 202: BIOCHEMISTRY & CELL STRUCTURE AND FUNCTION

(Credit 4)

Section A: Biochemistry (Credit 2)

Hours of teaching

1. Laws of thermodynamics and their applications **1**

1.1 Concept of free energy and calculations based on free energy change

2. Protein structure **6**

2.1 Primary structure, peptide bond
2.2 Secondary structure
2.2.1 α-helix, β-pleated sheet and bends
2.2.2 Prediction of secondary structure, Ramachandran plot

2.3 Tertiary structure
2.3.1 Forces stabilizing tertiary structure
2.3.2 Domains and motifs
2.4 Quaternary structure

3. Enzymes **6**

3.1 Enzyme kinetics
3.1.1 Lowering of activation energy
3.1.2 Derivation of Michaelis-Menten equation, related calculations And Michaelis-Menten and Lineweaver-Burk plots
3.2 Mechanism of action
3.2.1 Active site, substrate binding, transition state analogues and abzyme
3.2.2 Acid-base and covalent catalysis (chymotrypsin, carboxypeptidase)
3.2.3 Concepts of regulation of enzyme activity

4. Metabolism **3**

4.1 Concept of metabolic pathways
4.2 Energy transduction: glucose and fatty-acids as energy source

5. Nucleic acids

5.1 Structure, folding motifs, conformational flexibility and supercoiling **1**
5.2 Mechanism of DNA replication **3**
5.2.1 DNA polymerases
5.2.2 Origin of replication and formation of primosome
5.2.3 Replication fork and replisome
5.2.4 Termination of replication
5.3 Transcription unit **1**
5.4 Mechanism of transcription
5.4.1 RNA polymerases
5.4.2 Formation of pre-initiation complex at RNA pol II promoter
5.5 Processing of hnRNA **2**
5.5.1 Capping
5.5.2 Poly(A) tailing
5.5.3 Splicing
5.6 Genetic code **1**
5.7 Mechanism of translation **2**
5.7.1 Role of ribosomes and tRNAs
5.7.2 Formation of initiation complex
5.7.3 Elongation and termination

Books Recommended

1. Berg et al: Biochemistry (5th ed 2001, Freeman)
2. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2004, Pearson)
3. Mathews et al: Biochemistry (3rd ed 1990, Benjamin/Cummings)
4. Segal Biochemical calculations (2^{nd} ed 1976, John Wiley)
5. Watson et al: Molecular Biology of the Gene (2nd ed 1976, Benjamin/Cummings)
6. Zubay et al: Principles in Biochemistry (2nd ed 1995, WCB)
7. Rawn: Biochemistry (1989, Neil Patterson)
8. Primrose et al: Principals of gene manipulation (6th ed 2001, Blackwell Scientific)

Section- B: Cell Structure and Function (Credit 2)

Hours of teaching

1. Prokaryotes

1.1 Viruses: structure and replication **4**
1.1.1 Bacteriophage (Lambda phage, phi x 174)
1.1.2 Animal DNA virus (SV 40)
1.1.3 Retroviruses (HIV)
1.2. Bacteria **2**
1.2.1 Structure and reproduction of *E. coli*
1.2.2 Plasmid and their functions

2. Eukaryotes

2.1 Cell Membrane **4**
- 2.1.1 Lipid bi-layer and membrane proteins
- 2.1.2 Transport across the cell membrane
  - 2.1.2.1 Channels and transporters
  - 2.1.2.2 Diffusion, osmosis and measurement of osmotic pressure
  - 2.1.2.3 Active transport: mechanism and related calculations

2.2 Targeting and sorting of proteins **4**
- 2.2.1 Signal peptide and SRP dependent targeting of translational complex
- 2.2.2 Processing of proteins in RER
- 2.2.3 Processing through Golgi complex: targeting to plasma membrane and lysosome
- 2.2.4 Targeting of nuclear and mitochondrial proteins

2.3 Mitochondria **4**
- 2.3.1 Structure: assemblies of respiratory chain and F_0 F_1 - ATPase
- 2.3.2 Oxidative phosphorylation: mechanism and chemiosmotic concept
- 2.3.3 Bioenergetics of ATP and other high energy phosphate compounds.

2.4 Nucleolus: structure and biogenesis of ribosomes **1**

2.5 Cytoskeleton: organization of microtubules, microfilaments and intermediary filaments **1**

2.6 Cell signaling **3**
- 2.6.1 Cell-cell interaction
- 2.6.2 Chemical mediators
- 2.6.3 Signaling through cell surface and intracellular receptors

2.7 Apoptosis: mechanism and significance **2**

2.8 Cell transformation and malignancy **1**

Books Recommended

1. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)
2. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman)
3. Berg et al.: Biochemistry (5th ed 2002, Freeman)
4. Michael Jr: Microbiology (1993, Tata McGraw Hill)

ZOM 203: HISTOLOGY AND HISTOCHEMISTRY & BIOINFORMATICS

(Credit 3)

Section A: Histology and Histochemistry (Credit 1.5)

Hours of teaching

1. Fixation and tissue processing **3**
- 1.1 Types of fixatives
- 1.2 Chemistry of fixation
- 1.3 Choice of fixatives
- 1.4 Dehydration
- 1.5 Clearing and embedding

2. Microtomy **1**
- 2.1 Types of microtomes
- 2.2 Sectioning of paraffin blocks

3. Staining of paraffin sections **2**
- 3.1 Principle and methods of staining
- 3.2 Histological stains: haematoxylin and eosin

4. Principles and methods of histochemical localization and identification of the following

4.1 Carbohydrate moieties **2**
- 4.1.1 Glycogen and glycoproteins with oxidizable vicinal diols by periodic acid Schiff method
- 4.1.2 Glycoproteins with carboxyl groups and/or *O*-sulphate esters by alcian blue methods
- 4.1.3. Role of lectin in carbohydrate histochemistry

4.2 Protein end groups **2**
- 4.2.1 General protein localization by bromophenol blue method

4.2.2 –NH_2 groups by ninhydrin-Schiff method
4.2.3 – SS- groups by performic acid –Schiff and performic acid- alcian blue methods

4.3 Lipids moieties **2**
4.3.1 General lipids by Sudan black B method
4.3.2 Neutral lipids by Sudan III and Sudan IV methods
4.3.3 Differentiation of neutral lipids from acidic lipids by nile blue sulphate method

4.4 Nucleic acids **1**
4.4.1 Methyl green pyronin-Y for DNA and RNA
4.4.2 Feulgen reaction for DNA

4.5 Enzymes **3**
4.5.1 Principles of enzyme histochemistry
4.5.2 Acid and alkaline phosphatases by metal precipitation and azo dye methods

5. Basic principles of immunohistochemistry **2**

6. Enzyme as histochemical reagent **1**

Books recommended

1. Bancroft & Stevens: Theory and Practice of Histological techniques (2002, Churchill- Livingstone)
2. Casselman: Histochemical techniques (1959, John Wiley)
3. Pearse: Histochemistry: Theoretical and Applied (Vol. I, II & III) (4th ed 1980-1993, Churchill-Livingstones)

Section B: Bioinformatics
(Credit-1.5)

Hours of teaching

1. Introduction and scope of bioinformatics: a concept of digital laboratory **1**

2. Basics of computers (CPU, I/O units), operating systems (Windows, UNIX), networks (LAN, WAN) and information technology **3**

3. Concept of hypertext and internet protocol (HTTP, TCP/IP) **1**

4. Basics of home-pages, web-pages and uniform resource locators (URL) **1**

5. Introduction to data archiving systems (FASTA format, Accession, and GI-Number) **1**

6. Basic features and management systems of following **6**
6.1 Nucleic acid sequences databases
6.2 Genome databases
6.3 Protein sequence, structures and interacting proteins databases
6.4 Literature databases
6.5 Biodiversity and ecosystem based databases

7. Introduction to data retrieval systems **2**
7.1 Search engines
7.2 Entrez, sequence retrieval system (SRS) and protein identification resource (PIR)

8. Introduction to molecular sequence analysis software packages and tools **3**
8.1 Prediction of motifs, folds and domains
8.2 Sequence alignments (BLAST and Clustal W) and phylogenetic trees (PHYLIP)

9. Applications of bioinformatics **2**
9.1 Clinical informatics
9.2 Cheminformatic resources and pharmacoinformatics

Bioinformatics

1. Barnes & Gray: Bioinformatics for geneticists (2003, Wiley)
2. Lesk: Bioinformatics (2nd ed 2006, Oxford)
3. Westhead et al: Bioinformatics Instant Notes (Indian ed 2003, Viva Books)
4. Mount, Bioinformatics (2nd ed 2006, CBS)
5. Hunt and Livesey: Functional Genomics (2006, Oxford)
6. Campbel: Discovering Genomics, Proteomics and Bioinformatics (2006, LPE)

ZOM 204: MAMMALIAN PHYSIOLOGY & NEUROBIOLOGY

(Credit 4)

Section A: Mammalian Physiology (Credit 2.5)

	Hours of teaching
1. Circulation	**9**
1.1 Blood	
1.1.1 Haemopoiesis	
1.1.2 Haemostasis	
1.2 Lymph: composition and dynamics	
1.3 Heart	
1.3.1 Origin and conduction of cardiac impulse	
1.3.2 ECG and cardiac cycle	
1.3.3 Myocardial infarction	
2. Respiration	**7**
2.1 Pulmonary ventilation	
2.1.1 Respiratory centers: organization and function	
2.1.2 Surfactant	
2.2 Gaseous exchange	
2.3 Haemoglobin and gaseous transport	
2.4 Basal metabolic rate and its measurement	
2.5 Respiratory adjustments	
2.5.1 Hypoxia and oxygen therapy	
2.5.2 Dyspnea	
2.5.3 Respiratory buffering	
3. Excretion	**6**
3.1 Urine formation and regulation	
3.2 Acid-base balance and homeostasis	
3.3 Renal function tests	
4. Muscle	**5**
4.1 Types of contraction	
4.2 Muscle proteins	
4.3 Mechanism of contraction and energetics	
4.4 Muscular dystrophy	
5. Digestion and nutrition	**4**
5.1 Digestion and absorption of macronutrients and their regulation	
5.2 Obesity and starvation	

Section B: Neurobiology (Credit 1.5)

	Hours of teaching
1. Plasticity of brain and neurogenesis	**1**
2. Organization of nervous system	
2.1 Brain structure	
2.2 Neurons and glia	
2.3 Cerebrospinal fluid	
2.4 Neural network	
2.5 Blood brain barrier	
2.6 Autonomic nervous system	
3. Axonal and synaptic transmission	**5**
3.1 Types of neurons	
3.2 Membrane potential and action potential	
3.3 Types of synapses	
3.4 Excitatory and inhibitory post-synaptic potential	
3.5 Chemical transmission, neurotransmitters (acetylcholine, catecholamines, serotonin and GABA), neuropeptides	
4. Learning and memory: types and molecular basis	**2**
5. Brain and behavior: motivation and sleep	**2**
6. Brain imaging: CAT, PET and MRI	**2**

7. Brain aging **1**

8. Neuropathology **4**

8.1 Strokes
8.2 Epilepsy
8.3 Alzheimer disease
8.4 Huntington disease
8.5 Parkinson disease

Books Recommended

1. Ganong: Review of Medical Physiology (22nd ed 2005, Lang Medical Publications)
2. Guyton and Hall: Text Book of Medical Physiology (11th ed 2006, W.B. Saunders)
3. Keel et al: Samson Wright's Applied Physiology (13th ed1989, Oxford Press)
4. Murray et al: Harper's Illustrated Biochemistry (27th ed 1989, Appleton & Lange)
5. West: Best and Taylor's Physiological Basis of Medical Practice (11th ed 1981, Williams and Wilkins)
6. Longstaff: Neuroscience (2002, Viva Books)
7. Shepherd: Neurobiology(1994, Oxford Univ Press)
8. Squire et al: Fundamental Neuroscience(2003, Academic Press)
9. Eric Kandel: Principles of Neural Science (2000, Mc Graw Hill)

LABORATORY EXERSISES
ZOM 205: Cytogenetics & Genetics (Credit 2)

Part A: Cytogenetics

1. Study of meiosis in grasshopper testes by squashing method
2. Temporary squash preparation of polytene chromosomes from salivary glands of *Drosophila* larvae
3. Study of colchicinised metaphase chromosomes in bone marrow of rodent by air dry method
4. Preparation of human karyotype
5. Study of sex chromatin in human female from buccal epithelial and hair bud cells
6. Study of permanent slides for the following
   6.1 Dicentric bridge in the anaphase 1 chromosomes of grasshopper
   6.2 Inversion in polytene chromosomes
   6.3 Autoradiography detection of transcription in polytene chromosomes
   6.4 Lampbrush chromosomes of *Triturus* oocyte
   6.5 G-banded and C-banded metaphase chromosomes
   6.6 Chromatid exchanges and chromosomal anomalies
   6.7 Sister chromatid exchanges
   6.8 Replicon organization by DNA-fibre autoradiography
   6.9 Premature chromosome condensation

Part B: Genetics

1. Culturing of *E coli* on solid and liquid media
2. Demonstration of bacterial transformation using a suitable plasmid vector (with and without insert)
3. Handling of *Drosophila* and study of its life cycle
4. Examination of wild type (males and females) and mutants of *Drosophila*
5. Sex linked inheritance in *Drosophila melanogaster*
6. Linkage and crossing over in *Drosophila melanogaster*

ZOM 206: BIOCHEMISTRY & CELL STRUCTURE AND FUNCTION
(Credit 2)

Part A: Biochemistry

1. Preparation of extract for enzyme assay (alkaline phosphatase)
2. Study of alkaline phosphatase activity
   - 2.1 Standard curve preparation
   - 2.2 Effect of enzyme concentration and determination of total and specific activity
   - 2.3 Effect of pH on enzyme activity
   - 2.4 Effect of temperature on enzyme activity
   - 2.5 Effect of time on enzyme activity
   - 2.6 Effect of substrate concentration on enzyme activity
   - 2.7 Determination of Km and Vmax by Michaelis-Menten and Lineweaver-Burk Plot
3. Isolation of genomic DNA by spooling method and its characterization
   - 3.1 Determination of quality and quantity of DNA
   - 3.2 Determination of melting temperature (Tm)

Part B: Cell structure and Function

1. Study of bacterial growth curve
2. Study of types of testicular cells and striated muscle
3. Fractionation of macromolecules from rat/mouse tissues
4. Estimations of fractionated molecules through spectrophotometric methods
   - 4.1 Free phosphate by Amies method
   - 4.2 Protein by Biuret/Folins method
   - 4.3 DNA by diphenylamine method
   - 4.4 RNA by orcinol method

ZOM 207: HISTOLOGY AND HISTOCHEMISTRY & BIOINFORMATICS AND MAMMLIAN PHYSIOLOGY & NEUROBIOLOGY
(Credit 3)
Part A: Histology and Histochemistry & Bioinformatics (Credit 1.5)

Histology and Histochemistry

1. Paraffin sectioning
   - 1.1 Fixation of tissue blocks (e.g. intestine and stomach of rat or squirrel)
   - 1.2 Dehydration, clearing and embedding of tissue block in paraffin
   - 1.3 Sectioning of paraffin blocks, stretching and spreading of sections on slides
2. Histological staining of paraffin sections using haematoxylin and eosin method
3. Histochemical staining of paraffin sections for certain carbohydrate moieties using
   - 3.1 Periodic acid/Schiff's method for neutral glycoproteins
   - 3.2 Alcian blue pH 2.5 method for acidic glycoproteins
4. Histochemical staining for lipids using
   - 4.1 Sudan black B method
   - 4.2 Sudan III method
   - 4.3 Sudan IV method

Bioinformatics

1. Familiarization with computer operations and TCP/IP
2. Data archiving systems: FASTA format, WebIn, BankIT, Accession and GI numbers
3. Use of search engines (Google, Altavista, Dogpile, Meta-crawler)
4. Demonstration of web-pages related to biological information (NCBI, ExPasy)
5. Hands on practice to features of following databases
   GeneBank, PDB, DIP, PubMed, Toxnet, OMIM, Fly Base, AceDB, HGDB, MGDB, HGMD, LSD, MHCDB, KEGG, RNAdb

6. Hands on practice to features of following software packages/tools: BLAST, Clustal-W, PHYLIP, M-fold, GeneCards, NetChop

Part B: Mammalian Physiology & Neurobiology
(Credit 1.5)

1. Differential leucocytes counting in human blood
2. Determination of blood groups (ABO and Rh)
3. Estimation of ascorbic acid content in milk and lemon extract using titration method
4. Studies on frog skeletal muscle (gastrocnemius muscle preparation) contraction, and to observe the effects of increasing voltage, frequency of stimulus and load
5. Studies on frog heart beat *in situ,* and to observe the effects of acetylcholine and noradrenalin
6. Studies on action potential in isolated nerve fibers using cathode ray oscilloscope (CRO), and measurement of nerve impulse conduction
7. Studies on learning and memory in rat/mouse model by Morris-Water-Maze Test
8. a). Isolation of neurons and glia by differential centrifugation
   b). Characterization of isolated cells types using marker enzyme assay

MINOR ELECTIVES
(To be offered to students of other department in the Faculty)
ZOM 208M: HORMONES AND DISEASES
(Credit 3)

	Hours of teaching
1. Scope of endocrinology	**1**
2. Pituitary gland 2.1 General organization and hormones 2.2 Diseases: dwarfism, gigantism, acromegaly, diabetes insipidus	**6**
3. Thyroid 3.1 General organization and hormones 3.2 Diseases: goiter, myxoedema, cretinism	**5**
4. Parathyroid gland 4.1 General organization and hormones 4.2 Diseases: osteoporosis and tetany	**4**
5. Islets of Langerhans 5.1 General organization and hormones 5.2 Disease: diabetes mellitus (type I and type II)	**4**
6. Adrenal gland 6.1 General organization and hormones 6.2 Diseases: Addison's disease, Cushing's syndrome	**3**
7. Testis 7.1 General organization and hormones 7.2 Male infertility 7.3 Cryptorchidism	**4**
8. Ovary 8.1 General organization and hormones 8.2 Diseases: polycystic ovarian disease, hirsutism, and hyperandrogenism	**4**
9. Hormones and cancer	**2**
10. Hormones and stress	**2**
11. Obesity, and eating disorders	**2**
12. Melatonin, sleep disorders, and jet lag	**2**

Books Recommended

1. Hadley, M.C.: Endocrinology, Prentice Hall, International Edition, 2000
2. Wilson and Foster, Williams Text Book of Endocrinology 10th edition, W.B. Saunders Company Philadelphia, 2005

SEMESTER III

ZOM 301: DEVELOPMENTAL BIOLOGY & IMMUNOLOGY

(Credit 3)

Section A: Developmental Biology (Credit 2)

Hours of teaching

1. Fertilization in sea urchin and mammals **3**

1.1 Recognition of gametes and acrosomal reaction
1.2 Prevention of polyspermy and gamete fusion
1.3 Activation of egg metabolism

2. Early development **14**

2.1 Cleavage: patterns
2.2 Formation of blastula in amphibians
2.3 Gastrulation: fate maps, cell movement and formation of germ layers in echinoderms, ambhibians and birds
2.4 General concept of potency, commitment, specification, induction, competence and determination
2.5 Differentiation and pattern formation
2.5.1 Stalk and fruiting body formation in *Dictyostellium*
2.5.2 Origin of anterior-posterior and dorsal-ventral polarity in *Drosophila*: role of maternal, segmentation and homeotic genes
2.5.3 Organization of HOX gene in vertebrates
2.5.4 Axis formation in amphibians: Nieuwkoop Centre and primary organizer
2.5.5 Axis formation in birds and mammals: role of pattern forming genes

3. Late embryonic development
4

3.1 Vulva formation in *Caenorhabditis*
3.2 Formation of neural tube in vertebrates
3.3 Development of limb in vertebrates: role of HOX and other pattern forming genes

4. Hormonal regulation of metamorphosis in insects and amphibians **1**

5. Regeneration of Salamander limbs: polar coordinate model **1**

6. Senescence **1**

7. Stem cells and their applications **2**

Section B: Immunology (Credit 1)

Hours of teaching

1. Immune system **3**

1.1 Innate and adaptive immunity
1.2 Immune cells: types and production
1.3 Immune tolerance
1.4 Concept of clonal selection
1.5 Complement system

2. Humoral immunity **4**

2.1 Antigen and haptens
2.2 Primary and secondary response
2.3 Antibody: types, structure and functions
2.4 Generation of antibody diversity

2.5 Class switching

3. Cell mediated immunity **5**

3.1 T-cell receptors
3.2 MHC complexes
3.3 Antigen: processing and presentation
3.4 T helper cell and lymphocyte activation
3.5 Role of cytotoxic T-cell

4. Concept of vaccination **1**

Books Recommended

1. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)
2. Balinsky: An introduction to Embryology (5th ed 1981, Saunders)
3. Gilbert: Developmental Biology (8th ed 2006, Sinauers)
4. Kalthoff: Analysis of Biological development (1996, McGraw)
5. Wolpert: Principles of Development (3rd ed 2007, Oxford)
6. Abbas et al: Cellular and Molecular Immunology (2000, Saunders)
7. Elgert: Immunology understanding the Immune System (1996, Wiley)
8. Kuby: Immunology (6th ed 2007, Freeman)
9. Roitt: Essential Immunology (10th ed 2006, Mosby)
10. Roitt et al: Immunology (7th ed 2006, Mosby)

MAJOR ELECTIVE

ZOM 302A: BIOCHEMISTRY AND MOLECULAR BIOLOGY
Course I: Nucleic Acids
(Credit 3)

Hours of teaching

1. Eukaryotic genome **6**

1.1 Introduction to structural and functional genomics
1.2 Denaturation and renaturation of DNA, unique and repetitive DNA sequences (LINEs, SINEs)
1.3 Chromatin organization
1.3.1 Nucleosomes and higher order structures
1.3.2 Histones and non-histone chromosomal proteins
1.3.3 Telomere
1.3.4 Chromatin modifications

2. DNA replication **3**

2.1 DNA polymerases
2.2 ARS and initiation in yeast
2.3 Eukaryotic chromatin replication and regulation

3. DNA repair and recombination **2**

4. Human genome: mapping, characteristics and implications **2**

5. Transcription and its regulation **8**

5.1 RNA polymerases in eukaryotes
5.2 Transcription factors: general and specific
5.3 Assembly of pre-initiation complex and initiation
5.4 Elongation and elongation factors
5.5 Enhanceosomes
5.6 Transcriptome
5.7 Promoter analysis and characterization
5.7.1 Expression system: transient and stable
5.7.2 Deletion mapping
5.7.3 S1/RNase mapping
5.7.4 Chromatin immunoprecipitation (ChIP)
5.7.5 Electrophoretic mobility shift assay

5.7.6 DNase I footprinting

6. Post transcriptional processing and regulation **4**
6.1 Introns: types and mechanisms of splicing
6.2 RNA editing
6.3 Post transcriptional gene silencing (RNA interference)

7. Catalytic RNA and its role **1**

8. Genetic engineering
8.1 Tools **2**
8.1.1 Restriction enzymes and other enzymes for DNA manipulation
8.1.2 Vector types: cloning and expression
8.1.3 Probes
8.2 Cloning strategies **2**
8.2.1 cDNA and genomic libraries
8.2.2 Positional cloning
8.3 Screening of clones **2**
8.3.1 Preparation of probes
8.3.2 Hybridization: Southern, Northern (colony/plaque), immuno-screening
8.4 Characterization of clones **2**
8.4.1 Sequencing
8.4.2 Microarray
8.5 PCR and its applications **1**
8.6 Application: transgenic organisms and genetically modified organisms (GMOs), animal cloning, site-directed mutagenesis, generation of knock-out animals, gene therapy, DNA drugs **3**
8.7 Ethical and social issues **1**

Books Recommended

1. Malacinski: Freifelder's Essentials of Molecular Biology (4th ed 2005, Narosa)
2. Lewin: Genes IX (2008, Jones and Bartlett)
3. Brown: Genomes (3rd ed 2006, Garland Science)
4. Brown: Gene Cloning and DNA Analysis (2001, Blackwell)
5. Sambrook & Russell: Molecular Cloning (2001, Cold spring Harbor)
6. Primrose: Principles of Gene Manipulation (2001, Blackwell)
7. Asubel et al: Current Protocol in Molecular Biology (1994, Wiley)
8. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman)
9. Goldsby et al: Kubey Biochemistry (2001, Freeman)
10. Gesteland et al: RNA World (2nd ed 1999, Cold Spring Harbor)

ZOM 303A: BIOCHEMISTRY AND MOLECULAR BIOLOGY
Course II: Proteins and Cell Signaling
(Credit 3)

Hours of teaching

1. Purifications and characterization of proteins **2**

2. Protein structure **10**
2.1 Determination of primary structure
2.1.1 Amino acid composition
2.1.2 N- and C- terminal determination
2.1.3 Amino acid sequence determination
2.2 Forces and interactions involved in structural organization of fibrous and globular proteins
2.3 Structure function relationship
2.4 Protein denaturation
2.5 Molecular chaperones and protein folding
2.6 Post translational processing

3. Synthesis of proteins **4**
3.1 Translation

3.2 Chemical synthesis
3.3 Recombinant proteins: expression and application

6. Proteins in immune system **12**

6.1 B- and T- cells interaction in antibody synthesis
6.2 Immunoglobulin: genes and their diversity
6.3 Major histocompatibility complex, antigen processing
6.4 Complement proteins
6.5 Immunodeficiency diseases
6.6 Polyclonal and monoclonal antibody
6.7 Interferon
6.8 Immunotoxins

7. Cell signaling **11**

7.1 Signaling through intracellular receptors: lipophilic hormones
7.2 Signaling through cell surface receptors
7.2.1 G protein linked receptors: signaling via cAMP, PKA, IP3, Ca^{2+}/calmodulin, PKC, Ca-MK, ion channels (exemplified by vision)
7.2.2 Enzyme linked receptors
7.2.2.1 Receptor tyrosine kinase (RTK) signaling of growth factors
7.2.2.2 Tyrosine kinase associated receptors, JAK-STAT signalling pathway
7.2.2.3 Receptor protein tyrosine phosphatase (PTP)
7.2.2.4 Receptor serine/threonine kinase
7.2.2.5 Receptor guanyl cyclase, cGMP, PKG
7.2.2.6 Histidine kinase associated receptors, bacterial chemotaxis
7.3 Signaling by nitric oxide and carbon monoxide

Books recommended

1. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2006, MacMillan Worth)
2. Berg et al: Biochemistry (6th ed 2007, Freeman)
3. Mathews et al.: Biochemistry (6th ed 2006, Pearson)
4. Zubay et al: Biochemistry (4th ed 1998, WCB)
5. Horton et al: Principles of Biochemistry (4th ed 2006, Prentice Hall)
6. Mahler & Cordes: Textbook of Biological Chemistry (1966, Harper)
7. Albert et al: Molecular Biology of the Cell (5th ed 2007, Garland Publishing Inc)
8. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman and Company)
9. Murray et al: Harper's Illustrated Biochemistry (27th ed 2006, Appleton & Lange)
10. Kindt et al: Kuby's Immunology (2007, Freeman)
11. Voet and Voet: Biochemistry (2004, John Wiley)

ZOM 304A: BIOCHEMISTRY AND MOLECULAR BIOLOGY
Course III: Enzymology
(Credit 3)

Hours of teaching

1. Nomenclature and classification **1**

2. Mechanism of enzyme action **1**

2.1 Enzyme substrate binding
2.2 Binding energy, entropy change

3. Active site structure and determination: irreversible inhibitors, affinity labeling and suicide inhibitors **2**

4. Kinetics **6**

4.1 Single substrate reactions: steady state and equilibrium kinetics
4.2 Michaelis-Menten equation and plot
4.3 Linear kinetic plots: Lineweaver-Burk, Edie-Hofstee, Cornish-Bowden
4.4 Calculations on enzyme kinetics

5. Multi-substrate reactions **2**

5.1 Random sequential
5.2 Ordered
5.3 Theorel-Chance mechanism
5.4 Ping-pong (double reciprocal) mechanism

6. Enzyme inhibition **3**
6.1 Competitive; non-competitive; un-competitive and mixed
6.2 Determination of nature of inhibition and Ki by L-B and Dixon plots

7. Regulation: allosterism and covalent modifications **2**

8. Multi-enzyme complex and multifunctional enzymes **2**

9. Enzyme distribution, diversity and evolution **1**

10. Coenzymes and cofactors **2**

11. Principles and techniques of enzyme assay: fixed time, continuous and coupled assays **2**

12. Enzyme purification
12.1 Objective and strategy, choice of source **1**
12.2 Methods of homogenization **1**
12.3 Methods of separation on the basis of: solubility, size and mass, charge and specific binding **3**
12.4 Crystallization **1**
12.5 Evaluation of purification and selection of purification methods **3**
12.5.1 Recovery and fold of purification
12.5.2 Homogeneity of the purified enzyme
12.5.3 Determination of enzyme structure
12.6 Enzyme storage and stability *in vitro*

13. Enzyme technology
13.1 Enzyme immobilization: method and applications **2**
13.2 Enzyme engineering **2**
13.2.1 Modifications in active-site and introducing silent mutations
13.2.2 Application of enzyme engineering

Books Recommended

1. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2000, MacMillan Worth)
2. Berg et al: Biochemistry (5th ed 2002, Freeman)
3. Mathews et al.: Biochemistry (3rd ed 2004, Pearson)
4. Zubay et al: Principles in Biochemistry (2nd ed 1995, WCB)
5. Rawn: Biochemistry (1989, Neil Patterson)
6. Mahler & Cordes: Textbook of Biological Chemistry(1966, Harper)
7. Price & Stevens: Fundamentals of Enzymology (2nd ed 1988, Oxford University Press)
8. Engel: Enzyme kinetics: The steady state approach(1981, Chapman and Hall)
9. Segal: Biochemical calculations (2nd ed 1976, John Wiley)
10. Fersht: Enzyme Structure and Mechanisms (2nd ed 1985, Freeman)

MAJOR ELECTIVE

ZOM 302B: ENTOMOLOGY

Course I: Insect Physiology I

Hours of teaching

1. Digestive system **6**
1.1 Digestion
1.2 Absorption
1.3 Nutrition
1.3.1 Nutritional requirements
1.3.2 Ectosymbiotic fungi
1.3.3 Endosymbionts

2. Fat body: physiology and biochemistry **4**

3. Excretory system **8**

3.1 Organs of excretion
3.2 Nitrogenous excretion
3.2.1 Excretory products
3.2.2 Storage excretion
3.3 Production of urine and its hormonal regulation
3.3.1 Terrestrial and salt water insects
3.3.2 Control of diuresis
3.3.3 Water regulation
3.3.4 Detoxification

4. Circulatory system **13**

4.1 Circulation
4.2 Haemocytes
4.2.1 Type
4.2.2 Origin and longevity
4.2.3 Haemopoietic organs
4.2.4 Changes in haemocyte population
4.3 Immunity
4.3.1 Cell mediated immunity
4.3.2 Humoral immunity
4.4. Haemolymph proteins
4.4.1 Methods of study: protein purification, sequence analysis, immunological techniques
4.4.2 Storage proteins: synthesis, uptake and their role
4.4.3 Vitellogenin and its receptor mediated uptake by ovary
4.4.4 Antibacterial proteins
4.4.5 Lectins
4.4.6 Protease inhibitors
4.4.7 Enzymes in haemolymph
4.4.8 Peptides: neuropeptides and humoral factors
4.4.9 Chromoproteins
4.4.10 Specific transport proteins

5. Reproduction **8**

5.1 Anatomy of reproductive organs
5.2 Spermatogenesis and oogenesis
5.3 Mating, insemination, oviposition
5.4 Special modes of reproduction

ZOM 303B: ENTOMOLOGY

Course II: Insect Pests and their Management

(Credit 3)

Hours of teaching

1. Insect pests **2**

1.1 Causes of success of insects
1.2 Origin of insect pests
1.3 Factors affecting the abundance of insects

2. Insect pest control **4**

2.1 Natural control
2.2 Applied control
2.2.1 Cultural control: agronomic practices (crop rotation, tillage practice, planting/harvesting date manipulation, sowing/planting density, inter cropping, trap cropping and irrigation) **4**
2.2.2 Chemical control **4**
2.2.2.1 Formulations and insecticide toxicity
2.2.2.2 Botanical pesticide (pyrethrins, rotenone, sabadilla, nicotine and neem)
2.2.2.3 Synthetic organic insecticides and their mode of action (organchlorines, organophosphates, carbamates, pyrethroids and neonicotinoids)
2.2.2.4 Insect growth regulators (juvenoids, ecdysoids, antihormones and chitin inhibitors)
2.2.3 Biological control **5**

2.2.3.1 Parasites
2.2.3.2 Parasitoids
2.2.3.3 Predators
2.2.3.4 Methods for using biocontrol agents
2.2.3.4.1 Classical biological control
2.2.3.4.2 Augmentation and inoculation techniques
2.2.3.4.3 Conservation biological control
2.2.4 Microbial control (virus, bacteria and fungi) **5**
2.2.5 Behavioural control **3**
2.2.5.1 Types of pheromones
2.2.5.2 Uses of pheromones in pest management (monitoring, mass trapping and mating disruption)
2.2.6 Genetic and biotechnological control **3**
2.2.6.1 Methods of genetic manipulation
2.2.6.2 Transgenic plants with insecticidal genes
2.2.7 Insect attractants, repellents and antifeedants **2**
2.2.8 Integrated and biointensive integrated pest management **3**
2.2.8.1 Concept of injury levels
2.2.8.2 Integration of control tactics

ZOM 304B: ENTOMOLOGY

Course III: Industrial and Medical Entomology

(Credit 3)

Hours of teaching

1. Sericulture

1.1 Mulberry sericulture **7**
1.1.1 Cultivation of food plants
1.1.2 Rearing of silkworms
1.1.3 Harvesting and processing of cocoons
1.1.4 Reeling appliances
1.1.5 Genetic improvement of silkworms
1.1.6 Diseases of *Bombyx mori*
1.1.7 Predators and parasitoids of silkworm and their management
1.2 Non-mulberry sericulture **3**
1.2.1 Tasar sericulture
1.2.1.1 Cultivation of food plants
1.2.1.2 Rearing of tasar silkworms
1.2.1.3 Pupation and cocoon formation
1.2.1.4 Stifling and reeling of cocoons
1.2.2 Muga sericulture
1.2.2.1 Cultivation of food plants
1.2.2.2 Rearing of muga silkworms
1.2.2.3 Pupation and cocoon formation
1.2.2.4 Grainage technology
1.2.2.5 Stifling and reeling of cocoons
1.2.3 Eri sericulture
1.2.3.1 Cultivation of food plants
1.2.3.2 Rearing of eri silkworms
1.2.3.3 Pupation and cocoon formation
1.2.3.4 Stifling and reeling of cocoons

2. Apiculture **6**

2.1 Types of honeybees
2.2 Organization of bee colony
2.3 Life history and behaviour of bees
2.4 Dance language of honeybees
2.5 Diseases of honeybees
2.6 Beekeeping methods
2.6.1 Equipment and tools
2.6.2 Apiary management
2.6.2.1 Hiving a colony

2.6.2.2 Controlling swarming
2.6.2.3 Handling of bees
2.6.2.4 Extraction of honey and wax
2.7 Bee products

3. Lac culture **3**
3.1 Lac insect and its life history
3.2 Host plant management
3.3 Strains of lac insects
3.4 Propagation of lac insects
3.5 Lac crop management
3.6 Natural enemies of lac insects and their management
3.7 Lac extraction

4. Medical entomology **8**
4.1 Pests of public importance and their control: mosquitoes, house flies, lice, bedbugs, fleas
4.2 Insect borne diseases of man: typhus, yellow fever, dengue fever, encephalitis, plague, leishmaniasis, sleeping sickness, malaria, filaria,
4.3 Venoms and allergens
4.3.1 Insect venoms
4.3.2 Blister and urtica-inducing insects
4.3.3 Insect allergenicity

5. Household pests: cockroaches, ants, wasps, carpet beetles, furniture beetles and booklice **2**

6. Pest of farm animals and their control **3**
6.1 Blood-sucking flies
6.2. Myiasis flies
6.3. Lice
6.4. Fleas

7. Forensic entomology **2**
7.1 Arthropods of forensic importance
7.2 Insects succession on corpse and its relationship to determining time of death

8. Biotechnological applications **5**
8.1 Transgenesis
8.2 Insects as bioreactors
8.3 Insect cell culture

Books Recommended
(see list at the end of Course V: Agricultural Entomology)

ZOM 302C: FISH BIOLOGY

Course I: Culture Fisheries, Fish Nutrition and Fish Pathology

(Credit 3)

Hours of teaching

1. Fish culture systems
1.1 Ponds
1.1.1 Fish farm: construction and lay out of different types of ponds **4**
1.1.1.1 Formulation and operation of different types of hatcheries
1.1.1.2 Hatchery management
1.1.1.3 Brood pond management for culturable indigenous and exotic carps
1.1.2 Pond management **9**
1.1.2.1 Physico-chemical properties of pond water and soil and their maintenance
1.1.2.2 Manuring (organic and inorganic) and liming
1.1.2.3 Composite fish farming and polyculture
1.1.2.4 Predatory and weed fishes and their eradication
1.1.2.5 Aquatic vegetation and its control
1.1.2.6 Biological means of increasing production
1.2. Other systems: cage, raft, pens, raceways **4**

2. Fish culture in paddy fields **1**

3. Sewage-fed fisheries **1**

4. Exotic fishes and their role in fish farming **2**

5. Larvivorous fishes **1**

6. Nutrition and feeds **9**

6.1 Physiological roles of nutrients
- 6.1.1 Food and feeding habits of freshwater fishes, prawn, mussel and oysters
- 6.1.2 Nutrient requirement (proteins, lipids, carbohydrates, minerals and vitamins) for various growth stages of freshwater carps, prawns and mussels
- 6.1.3 Nutritional bio-energetics
- 6.1.4 Presence of anti nutritional factors and their removal procedures

6.2 Supplementary feed
- 6.2.1 Kind of supplementary feeds
- 6.2.2 Formulation and processing, storage and quality control of feeds

7. Fish pathology, prophylaxis and therapy **8**

7.1 Protozoan diseases of fish
- 7.1.1 Cyclochaetiasis, Costiasis, (sliminess of skin)
- 7.1.2 Ichthyophthiriasis (white spot disease)

7.2 Helminth parasites of fish
- 7.2.1 *Gyrodactylus*
- 7.2.2 *Dactylogyrus*
- 7.2.3. Nematodes

7.3 Crustacean parasites of fish
- 7.3.1 Lernaea
- 7.3.2 Ergasilus

7.4 Fungal diseases of fish
- 7.4.1 Saprolegniasis
- 7.4.2 Branchiomycosis (gill rot)

7.5 Bacterial diseases of fish
- 7.5.1 Tail and fin rot
- 7.5.2 Dropsy
- 7.5.3 Furunculosis

7.6 Viral diseases of fish
- 7.6.1 Papillomatosis (cauliflower disease)
- 7.6.2 Pox disease

7.7 Nutritional diseases of fish
- 7.7.1 Avitaminoses
- 7.7.2 Intoxication

ZOM 303C: FISH BIOLOGY

Course II: Fish Physiology I (based on teleost)

(Credit 3)

Hours of teaching

1. Integument

1.1 Epidermis
- 1.1.1 Mucogenic **2**
- 1.1.2 Keratinized **2**

1.2 Dermis
- 1.2.1 General organization **1**
- 1.2.2 Scales **1**
- 1.2.3 Chromatophores **2**

2. Respiration

2.1 Aquatic respiration
- 2.1.1 Gills **3**

2.1.2 Mechanisms of respiration **3**

2.1.2.1 Counter current principle
2.1.2.2 Water flow across the gills
2.1.2.3 Respiratory pump
2.1.2.4 Pump musculature and skeleton
2.1.2.5 Gas exchange

2.2. Air-breathing

2.2.1 Accessory respiratory organs and respiratory epithelium **3**

2.2.2 Physiological adaptation in air-breathing fishes **2**

2.3. Transport of respiratory gases

2.3.1 Transport of oxygen **1**

2.3.2 Transport of carbon dioxide **1**

3. Digestion

3.1 Alimentary canal and its modifications in relation to food and feeding habits **2**
3.2 Digestive fluids and enzymes **2**
3.3 Digestion and absorption of lipid, protein and carbohydrate **2**
3.4 Gastrointestinal motility control

4. Swim bladder

4.1 General organization and circulation **1**
4.2 Composition of swim bladder gas, its secretion and maintenance **1**
4.3 Removal of gas from swim bladder **1**
4.4 Functions of swim bladder **1**

5. Circulation

5.1 Heart and aortic arches **1**
5.2 Regulation of cardiac activity **1**
5.3 Hemodynamics **1**
5.4. Cardiac output **1**
5.5. Circulation time **1**
5.6. Blood pressure **1**
5.7. Fish haemoglobin **1**

ZOM 304C: FISH BIOLOGY

Course III: Fish Reproduction, Breeding and Biotechnology
(Credit 3)

Hours of teaching

1. Functional morphology of gonads of teleosts

1.1 Gametogenesis **2**
1.2 Role of environmental factors (photoperiod, temperature, rainfall, salinity) on gonad maturation **2**
1.3 Gonadal steroidogenesis and its control **2**

2. Role of hypothalamo-hypophyseal hormones in reproduction **2**

3. Reproductive behavior and pheromones **2**

4. Types and mode of reproduction **1**

5. Secondary sexual characters	**1**
6. Sexuality: intersex, bisexuality, hermaphroditism	**2**
7. Parental care	**1**
8. Induced breeding	**7**
8.1Factors responsible for induced breeding	
8.2 Hypophysation	
8.3 Use of different synthetic and natural hormones, their formulation and mechanism of action	
8.4 Bundh breeding	
8.5 Hapa breeding	
8.6 Hatchery breeding	
9. *In vitro* fertilization and incubation	**1**
10. Fish seed collection, transport of brood fishes and fish seed	**3**
11. Fundamentals of fish genetics	**2**
12. Fish biotechnology	**7**
12.1 Gynogenesis.	
12.2 Androgenesis	
12.3 Polyploidy	
12.4 Production of monosex population	
12.5 Hybridization	
12.6 Cryo-preservation of gametes and embryo	
12.7 Transgenic fish	
13. Age and growth	
13.1 Growth rate and aging	**2**
13.2 Length weight relationship	**1**
13.3 Gonadosomatic index	

ZOM 302D: MOLECULAR ENDOCRINOLOGY AND MAMMALIAN REPRODUCTIVE PHYSIOLOGY

Course I: Neuroendocrinology and Non-classical Hormones
(Credit 3)

	Hours of teaching
1. Neuroendocrinology	
1.1 Hypophysiotropic hormones: localization, secretion and mechanism of action	**12**
1.1.1 TRH	
1.1.2 GnRH	
1.1.3 CRH	
1.1.4 GHRH and PACAP	
1.1.5 Somatostatin	
1.1.6Monoamines	
1.2 Adenohypophysis	**10**
1.2.1 Role of transcription factors in pituitary differentiation	
1.2.2 Paracrine/autocrine secretions	
1.2.3 Neural control of ACTH, TSH, prolactin and growth hormone	
1.3 Pineal gland	**4**
1.3.1 Pineal, biological clock and calendar	
1.3.2 Melatonin and photoperiodic measurement	
2. Non - classical hormones	**13**
2.1 Growth factors: cellular origin, secretion and functions	
2.1.1 Epidermal growth factor family (EGF and TGFα)	
2.1.2 Transforming growth factor β family (TGF β, anti-Mullerian hormone, inhibins and activins)	
2.1.3 Platelet-derived growth factor family	
2.1.4 Fibroblast growth factor family	
2.1.5 Insulin family (IGF-1 and IGF-II)	

2.1.6 Nerve growth factor family
2.1.7 Hematopoietic growth factors (erythropoietin, thrombopoietin and colony stimulating factor)
2.1.8 Immunoinflammatory hormones (interleukines, TNFα and TNFβ)
2.2 Eicosanoids (prostaglandins, thromboxanes and leukotrines)
2.3 Leptin

Books recommended

1. Bolander: Molecular Endocrinology (3rd ed 2006, Elsevier)
2. DeGroot and Jameson: Endocrinology (5th ed 2006, Vol 1, Elsevier-Saunders)
3. Larson. Williams Textbook of Endocrinology (10th ed 2002, Saunders
4. Norman and Litwack. Hormones(2nd ed 1997, Academic press)
5. Henson and Castracane: Leptin and Reproduction (2003, Plenum,Publishers)

ZOM 303D: MOLECULAR ENDOCRINOLOGY AND MAMMALIAN REPRODUCTIVE PHYSIOLOGY

Course II: Male Reproduction
(Credit 3)

Hours of teaching

1. Gonadotropins: structure, secretion and regulation **4**

2. Testis **16**
2.1 Spermatogenesis and hormonal regulation
2.2 Sertoli cell
2.3 Leydig cell
2.4 Cell – cell interactions

3. Epididymis: organization and function **6**

4. Male accessory sex glands **4**
4.1 Structural organization and endocrine regulation of prostate
4.2 Functions of accessory sex glands

5. Sexual differentiation and behaviour **9**
5.1Gonadal differentiation
5.2 Brain differentiation
5.3 Copulatory patterns
5.4 Hormones in sexual behaviour
5.5 Sites of action of sex hormones

ZOM 304D: MOLECULAR ENDOCRINOLOGY AND MAMMALIAN REPRODUCTIVE PHYSIOLOGY

Course III: Female Reproduction
(Credit 3)

Hours of teaching

1. Reproductive cycles **3**
1.1 Menstrual cycle
1.2 Control of seasonal reproductive cycle
1.2.1 Photoperiod and temperature
1.2.2 Food supply

2. Hormonal control of puberty and pregnancy **4**

3. Regulation of ovarian function **16**
3.1 Follicular development and selection
3.2 Regulation of steroidogenesis
3.3 Oocyte maturation
3.4 Mechanism of ovulation
3.4.1 Hormonal and molecular changes during periovulatory period
3.4.2 Factors involved in follicular rupture

3.5 Follicular atresia

4. Fertilization **6**

4.1 Hormonal control of gamete interaction
4.2 Role of zona proteins
4.3 Gamete activation
4.4 Sperm-egg fusion

5. Biology of implantation **10**

5.1 Cellular aspects
5.2 Molecular aspects
5.3 Markers of developing embryo
5.4 Cross-talk between embryo and uterus

ZOM 302E: MOLECULAR AND HUMAN GENETICS

Course I: Human Genetics
(Credit 3)

Hours of teaching

1. History of human genetics **1**

2. Patterns of inheritance **10**

2.1 Pedigree construction, inheritance patterns (autosomal, sex-linked, sex-limited and sex- influenced), and risk assessment
2.2 Mitochondrial inheritance
2.3 Complexities associated with inheritance (penetrance and expressivity, new mutations, anticipation, co-dominance, pseudo-dominance, genetic heterogeneity, imprinting, Lyonisation, mosaicism and chimerism)
2.4 Consanguinity and its effects

3. Complex traits **10**

3.1 Oligogenic and polygenic traits
3.2 Multifactorial traits: nature-nurture concept
3.2.1 Family, twin and adoption studies
3.2.2 Genetic susceptibility, heritability, and empiric risk
3.2 Threshold trait

4. Mapping and identifying a disease gene **15**

4.1 Genetic mapping of the locus
4.1.1 DNA markers: RFLP, microsatellites, SNPs
4.1.2 LOD score analysis, linkage disequilibrium mapping (haplotype analysis)
4.2 Genetic mapping of complex traits: affected sib-pair method, association studies
4.3 Cloning the disease gene: functional, positional, and candidate gene approach
4.4 Identifying and confirming the disease gene: mutation detection, validation in animal model systems

5. Pharmacogenetics and ecogenetics **3**

ZOM 303E: MOLECULAR AND HUMAN GENETICS

Course II: Genomics and Molecular Genetic Techniques
(Credit 3)

Hours of teaching

Section A: Genomics (Credit-2)

1. Diversity of genomes **12**

1.1 Overview of pro- and eukaryotic genomes
1.1.1 Comparative genomics of pro- and eukaryotes
1.1.2 Human genome mapping strategies (genetic and physical mapping)

1.2.3 Annotation of human genome
1.2.4 Integrated map and organization of human genome
1.2 Modes of genomic innovations
1.2.1 Mutations
1.2.2 Gene duplication: gene families, pseudogenes
1.2.3 Transposable elements: prokaryotes, yeast, *Drosophila*, human
1.2.4 Horizontal transfer among genomes

2. Genomic expression profiling **12**

2.1Concepts of transcriptome and proteome
2.2 Microarray analysis, 2D-electrophoresis, protein sequencing, mass spectrometry
2.3 Prediction, diversity and multiplicity of protein functions
2.4 Sequence homology and predictions of gene functions
2.5 Applications in human disease

3. Metabolomics and global biochemical networks (human perspective) **2**

Section B: Molecular Genetic Techniques (Credit 1)

1. DNA Techniques **3**

1.1 Oligonucleotide synthesis
1.2 DNA sequencing
1.3 DNA fingerprinting
1.4 Expression of recombinant proteins

2. Gene function analysis
10

2.1 DNA-protein and protein-protein interactions: gel mobility shift assay, foot printing, western and south-western blotting, Yeast 2-hybrid system
2.2 Random mutagenesis, mutation screens, complementation and suppression
2.3 Manipulation of genes, site-specific mutagenesis, transgenesis
2.4 Targetted mutagenesis, gene knockout and gene knock-in methods
2.5 Reporter genes and temporal/site specific expression
2.6 RNAi and specific gene silencing
2.7 Mitotic recombination and generation of somatic clones for developmental studies in *Drosophila*
2.8 Nomenclature of gene mutations and chromosome rearrangements in *Drosophila*;balancer chromosomes

ZOM 304E: MOLECULAR AND HUMAN GENETICS

Course III: Developmental Genetics and Gene Expression
(Credit 3)

Hours of teaching

Section A: Developmental Genetics (Credit 1.5)

1. Genetic control of embryonic development and pattern formation **2**

2. Epigenetic modifications **6**

2.1 Imprinting
2.2 Endoreplication and amplification
2.3 Chromatin diminution
2.4 Programmed DNA rearrangements

3. Sex determination and dosage compensation in *Caenorhabditis*, *Drosophila* and mammals **6**

4. Medical implications of developmental genetics **5**

3.1 Infertility
3.2 Teratogenesis
3.3 Stem cells and tissue engineering

Section B: Gene Expression (Credit 1.5)

1. Regulation of transcription and gene expression

1

0

1.1 Chromatin remodelling and gene expression
1.2 Activators and repressors of transcription
1.3 Regulation of gene expression by steroid hormones, temperature shock
1.4 Regulation of lysogenic-lytic cycle in lambda phage

2. Post-transcriptional processing **7**

2.1 RNA binding proteins and RNA motifs
2.2 Transcription attenuation
2.3 Splicing, alternative splicing and trans-splicing
2.4 Processing of pro- and eukaryotic rRNA and tRNAs
2.5 RNA editing
2.6 RNA targeting
2.7 mRNA stability
2.8 RNAi and RNA degradation

3. Post-translational processing **3**

3.1Codon usage and codon bias
3.2Protein folding and molecular chaperons
3.3Protein processing
3.4Protein degradation

LABORATORY EXERCISES
ZOM 305: DEVELOPMENTAL BIOLOGY & IMMUNOLOGY
(Credit 2)

Part A: Developmental Biology (Credit 1.5)

1. Collection of frog spawns and observation of different developmental stages
2. Study of embryonic developmental stages in frog through models
3. Study of spiral cleavage in eggs of snail
4. Study of effect of thyroxine and antithyroid drug on metamorphosis
5. Effect of vitamin A in tadpole tail regeneration
6. Study of embryonic development in chick through slides
7. Window preparation to study chick embryo development
8. Whole mount preparation of chick embryos at various stages of development
9. Cuticular preparation of *Drosophila* embryos and studying segmentation defects in developmental mutants
10. Study of expression of the developmental genes in larval imaginal discs and pharate adults
11. Observation and mounting of aristapedia and bithorax mutants of *Drosophila*
12. Study of role of ecdysone in metamorphosis by ligature experiments using maggots/*Drosophila* larvae

Part B: Immunology (Credit 0.5)

1. Separation of macrophages from mice and their identification on the basis of non specific esterase staining
2. Immunization of rabbit and collection of antisera
3. Demonstration of antigen-antibody reaction by immunodiffusion
4. Demonstration of direct ELISA
5. Demonstration of western blotting

MAJOR ELECTIVE LABORATORY EXERCISES
ZOM 306A: BIOCHEMISTRY AND MOLECULAR BIOLOGY
Course I (Credit 3)

Part A: Nucleic acids

1. Sterilization techniques, media preparation and agar plate preparation
2. Measurement of growth curve of *E.coli*., calculation of its generation time and viable cell counting
3. Induction of β-galactosidase in *E.coli*
4. Rapid isolation of plasmid DNA (mini prep. alkaline lysis method)

5. Restriction digestion of plasmid and analysis by agarose gel electrophoresis, determination of insert size
6. Cloning of a DNA fragment
7. Preparation of competent cells, transformation and screening of colonies (blue-white selection)
8. Demonstration
   8.1 Southern hybridization
   8.2 PCR

Part B: Proteins and Cell Signaling

1. Purification of nuclei from mouse/rat tissues, quantitation and characterization
2. Isolation of total histones
3. Fractionation of core histones and histone H1
4. Electrophoretic analysis of total histones and histone H1
5. Isolation of non-histone chromosomal proteins (high mobility group proteins) and electrophoretic analysis
6. Studies on the expression of protein by western blotting
7. Studies on quantitation of proteins by various methods : Biuret, Lowry, Bradford, Bromcresol and UV spectrophotometry
8. Studies of effects of interfering agents such as salts, detergents, reducing agent (β-mercaptoethanol/dithiotheritol), urea, etc on the protein estimation methods
9. Measurement of nitric oxide in normal and pathological conditions using rat/mouse model
10. Spectrophotometric and ELISA based assay of nitric oxide synthase in normal and pathological conditions using rat/mouse model
11. Analysis of expression of cMyc/cFos in normal and pathological conditions using rat/mouse model

Part C: Enzymology

1. Tissue collection, storage and processing and preparation of enzyme extract
2. Standardization of the assay procedure
3. Determination of total activity and specific activity
4. Tissue distribution and sub-cellular distribution of enzyme activity.
5. Development and standardization of purification protocol
6. Enzyme purification and determination of fold of purification and percent recovery.
7. Kinetic studies

ZOM 306B: ENTOMOLOGY
Course I (Credit 3)

Part A: Insect physiology I

1. Study of internal anatomy of different stages of hemi and holometabolous insects
2. Preparation of stained histological slides of
   2.1 Alimentary canal of cockroach (fore gut, mid gut and hind gut).
   2.2 Salivary apparatus of cockroach and *Dysdercus.*
   2.3 Malpighian tubules of cockroach
   2.4. Blood cells of cockroach.
   2.5 Reproductive organs of hemi and holometabolous insects
   2.6 L.S. telotrophic and polytrophic ovarioles
   2.7 Testis of cockroach and *Dysdercus*.
3. Demonstration of amylase and proteinase activities of salivary gland of cockroach.
4. Study of morphology of eggs of *Drosophila*, cockroach and *Dysdercus*.
5. Protein profiling of hemolymph during development

Part B: Insect Pests and their Management

1. Collection and preservation of insects by
   1.1 Dry preservation methods (direct pinning, carding and pointing)
   1.2 Liquid preservation and processesed mounting methods
2. Study of key features of insects belonging to economically important insect orders (Orthoptera, Hemiptera, Lepidoptera, Hymenoptera, Diptera)
3. Measurement of oxygen consumption in lindane-treated cockroach
4. Study of repellent effect of oil of citronella on mosquito

5. Study of antifeedant effect of neem extract on grasshoppers
6. Determination of LC_{50} of Rogor using *Drosophila melanogaster* larvae or *Tribolium* sp.
7. Comparison of toxicity effects of lindane and malathion on *Tribolium* sp.

Part C: Industrial and Medical Entomology
1. Study of food utilization by silkworm *Bombyx mori*
2. Rearing of silkworm
3. Study of silk glands and their proteins in different larval stages of *B. mori*
4. Study of pre- and post-cocooning characteristics of *B. mori*
5. Study of fecundity of silk moth *B. mori* reared on different varieties of mulberry leaves
6. Study of silkworm diseases using permanent slides/specimen
7. Visit to a local silkworm rearing centre
8. Study of external morphology of different castes of honey bee and preparation of a permanent mount of sting apparatus
9. Visit to a local apiculture centre to study bee keeping and apiary management
10. Study of life cycle of mosquitoes/house flies and their habitats
11. Visit to a local diary farm to study farm animal pests and their control

ZOM 306C: FISH BIOLOGY
Course I (Credit 3)

Part A: Culture Fisheries, Fish Nutrition and Fish Pathology
1. Seasonal analyses of pond water by measuring the following physico-chemical properties:
   1.1 Dissolved CO_2 content
   1.2 O_2 content
   1.3 Alkalinity
   1.4 pH
2. Identification of common aquatic vegetation of ponds
3. Study of locally available weed and predatory fishes
4. Study of locally available larvivorous fishes
5. Collection, mounting and study of helminth parasites infecting locally available fishes
6. Identification of locally available fishes of economic importance
7. Determination of feeding habit of important edible fishes by morphological analyses of their buccopharyngeal region
8. Determination of feeding habit of carps and catfishes by analyses of their gut contents

Part B: Fish Physiology I (based on teleost)

1. Dissection and display of afferent and efferent branchial vessels of a carp and a catfish
2. Preparation of permanent stained slides of skin, gills, spleen, digestive tract (stomach and intestine), liver, gonads of *Heteropneustes fossilis* or *Clarias batrachus*
3. Determination and comparison of hemoglobin content of water-breathing and air breathing fish
4. Study of ventilation rate and surfacing activity of a air-breathing fish under different experimental conditions

Part C: Fish Reproduction, Breeding and Biotechnology
1. Determination of fecundity in major carp and catfish
2. Determination of fertilization rate of carp
3. Determination of final oocyte maturation by scoring germinal vesicle breakdown
4. Study of functional morphology of testes and ovary by preparing permanent stained slides belonging to different reproductive phases
5. Determination of gonosomatic index and hepatosomatic index and their relations with regard to gonadal and body growth
6. Demonstration of induced breeding at a seed production centre
7. Visit to a fish farm and hatchery
8. Study of length weight relationship of major carp and catfish

ZOM 306D: MOLECULAR ENDOCRINOLOGY AND MAMMALIAN REPRODUCTIVE PHYSIOLOGY
Course I (Credit 3)

Part A: Neuroendocrinology and Non-classical Hormones

1. Study of pituitary and pineal cell types through prepared slides
2. *In situ* study of pituitary gland
3. Transplantation of pituitary in kidney capsule
4. *In situ* study of pineal gland and associated epithalamic complex
5. Demonstration of pinealectomy
6. Demonstration of pituitary cell dispersal and separation by percoll density gradient
7. Anatomical mapping of hypothalamic centres (SON, PVN, AR, VMO, mammillary nucleus, median eminence)
8. Deaffarentation of MBH
9. Demonstration of hypothalamic monoamines/neuropeptides by HPLC
10. Ascorbic acid depletion bioassay for LH
11. Pigeon crop-sac bioassay for prolactin
12. ELISA/RIA of TSH or gonadotropins
13. Demonstration of growth factors in ovary/testis by ICC

Part B: Male Reproduction

1. Preparation of permanent slides of reproductive organs: testis, epididymis (caput, corpus, and cauda), seminal vesicle and prostate
2. Study of stages of spermatogenesis and spermiogenesis using histological slides of testis
3. Biochemical estimation of fructose and alkaline and acid phosphatases in seminal vesicle and prostate
4. Study of effect of epididymal ligation on microscopic features of epididymis
5. Study of the following using permanent slides: testis, epididymis, seminal vesicle, prostate and Cowper′s gland
6. Androgen bioassay by sialic acid assay
7. Biochemical estimation of 3β-hydroxyl steroid dehydogenase
8. Demonstration of lordosis in androgenized female rat

Part C: Female Reproduction

1. Study of rat oestrous cycle using vaginal smear preparations
2. Studies on follicular development using sections of rat ovary
3. Studies on permanent slides of female reproductive organs (ovary, uterus, oviduct and vagina)
5. Ovariectomy and hormone replacement therapy in rat
6. Isolation of large antral follicle and corpus luteum
7. Isolation of egg, granulosa and theca cells
8. Induction of pseudopregnancy and pregnancy and comparison of progesterone levels
9. Demonstration of different stages of preimplantation embryos in mouse
10. Demonstration of implantation sites by pontamine blue (blue dye reaction) in mouse
11. Induction of decidualization in rat
12. *In vitro* culture of ovarian follicles
13. Effect of anti-histamines/anti-prostaglandins on ovulation
14. SDS-PAGE analysis of ovarian proteins
15. Biochemical estimation of protein, cholesterol and total lipids

ZOM 306E: MOLECULAR AND HUMAN GENETICS
Course I (Credit 3)

Part A: Human Genetics

1. Estimation of frequency of common genetic traits in local human population
2. Construction of pedigrees for selected traits and analysis of inheritance patterns
3. Calculation of Mendelian risk from the prepared pedigrees
4. Study of multifactorial trait (analysis of fingerprint patterns of random individuals)
5. Study of threshold trait (cleft-lip/palate)
6. Dysmorphology and dermatoglyphic studies in Down and Turner syndromes

7. Extraction of DNA from lymphocytes
8. Southern hybridization of a non-radioactive labelled probe with the extracted genomic DNA
9. Demonstration of inheritance patterns using microsatellite markers and SNPs

Part B : Genomics and Molecular Genetic Techniques

1. Familiarity with laboratory instruments and usage of micropipettes; preparation of laboratory reagents
2. Cleaning and autoclaving of glasswares, preparation of culture media and plates for bacterial work
3. Ligation of an insert in a suitable cloning vector
4. Preparation of competent cells and transformation using recombinant plasmid
5. Minipreparation of plasmid DNA
6. DNA extraction from *Drosophila*
7. Quantitation of DNA on agarose gel using spectrophotometer
8. DNA sequencing (demonstration)
9. Sequence homology search and prediction of gene function
10. Zoo-blot to study sequence conservation
11. Study of DNA methylation in human genome
12. Extraction of mitochondrial DNA and its restriction mapping

Part C: Developmental Genetics and Gene Expression

1. Differentiation in *Dictyostellium*
2. Development of *Caenorhabditis*
3. RNA:RNA *in situ* hybridisation to study tissue specific expression of genes
4. RT-PCR based study of gene expression during mouse development
5. Restriction enzyme based detection of methylated DNA
6. Identification of different embryonic stages of *Drosophila*
7. Study of conditionally driven gene expression using UAS-GAL4 system by GFP fluorescence and/or lacZ staining
8. SDS-PAGE analysis of protein profiles in mouse or heat shocked *Drosophila* larvae
9. Analysis of cellular proteins from mouse/*Calotes* by 2D-gel electrophoresis
10. Induction of enhancer/protein-trap mutations in *Drosophila* by P-transposon mobilization
11. Preparation of polytene chromosomes from salivary glands of *Drosophila melanogaster* larvae and identification of different arms
12. Localization of P-transposon insertion on polytene chromosomes of *Drosophila melanogaster* by *in situ* hybridization
13. Heat shock response in *Drosophila*
14. Quantitative comparison of gene expression using Real-Time PCR

SEMESTER IV

ZOM 401: ANIMAL BEHAVIOUR & ENVIRONMENTAL BIOLOGY

(Credit 3)

Section A: Animal Behaviour

(Credits 1.5)

	Hours of teaching
1. Introduction to behaviour	**1**
2. Patterns of behaviour	**1**
3. Genetic and neural basis of behaviour	**5**
3.1 Genetic basis	
3.2 Bird song development	
3.3 Biological rhythms	
4. Habitat selection and foraging behaviour	**3**
5. Animal signals and communication	**3**
5.1 Evolution of animal signals	
5.2 Honesty and deceit in communication	
6. Sexual conflict	**3**
6.1 Parental care	
6.2 Sexual selection	

7. Social organization **3**
7.1 Theories of social behaviour
7.2 Altruism in eusocial animals

Section B: Environmental Biology
(Credit 1.5)

Hours of teaching

1. Introduction to environmental biology **1**

2. Ecological principles **2**
2.1 Concept of ecosystem
2.2 Energy flow

3. Population ecology **6**
3.1 Population dynamics
3.1.1 Population growth form
3.1.2 r- and k-selections and carrying capacity
3.2 Biological communities and species interactions
3.2.1 Types of interactions between two species
3.2.2 Interspecific competition

4. Environmental health and toxicology **4**
4.1 Types of environmental health hazards
4.2 Pollution: air, water, solid waste and radioactive
4.3 Bioaccumulation and biomagnification

5. Conservation and management of natural resources **7**
5.1 Soil and mineral resources
5.2 Biodiversity: benefits and threats
5.3 Endangered species management and biodiversity protection

Books Recommended

Animal Behaviour:

1. Alcock : Animal Behaviour: An Evolutionary Approach (7th ed 2005, Sinaur)
2. Bolhuis & Giraldeau: The Behavior of Animals: mechanisms, function, and evolution (2005, Blackwell)
3. Drickamer & Vessey: Animal Behaviour –Concepts, Processes and Methods (2nd ed 1986, Wadsworth)
4. Drickamer, Vessey & Jakob: Animal Behavior: Mechanisms, Ecology, Evolution (2007, McGraw-Hill)
5. Gadagkar: Survival Strategies: Cooperation and Conflict in Animal Societies. (1998, Universities Press)
6. Goodenough et al: Perspectives on Animal Behaviour (1993, Wiley)
7. Grier: Biology of Animal Behaviour (1984, Mosby)
8. Krebs & Davis: Behavioural Ecology. (3rd ed 1993, Blackwell)
9. Lehner: Hand Book of Ethological Methods.(2nd ed 1996, Garland)
10. Manning & Dawkins: An introduction to Animal Behaviour (5th ed 1998, Cambridge Univ. Press)
11. Slater & Halliday: Behaviour and Evolution (1st ed 1994, Cambridge Univ. Press)

Environmental Biology:

1. Cunningham and Saigo: Environmental Science (5th Ed., McGraw Hill, 1999).
2. Odum : Fundamentals of Ecology (Saunders, 1971).
3. Odum and Barett: Fundamentals of Ecology (EWP, 2005).
4. Primark : A Primer of Conservation Biology (2nd Ed., Sinauer, 2004).
5. Raven, Berg, Johnson: Environment (Saunders. 1993).
6. Sharma: Ecology and Environment (7th Ed., Rastogi, 2000).
7. Turk and Turk: Environmental Science (4th Ed., Saunders, 1993).

8. Wright and Nebel: Environmental Science (8th Ed., Prentice Hall, 2002).

ZOM 402: EVOLUTION & PARASITOLOGY

(Credit 3)

Section A: Evolution

(Credit 2)

	Hours of teaching
1. An overview of evolutionary thoughts, development and the concept of synthetic theory.	**2**
2. Population genetics	**3**
2.1 Gene frequencies in Mendelian population	
2.2 Hardy-Weinberg equilibrium	
2.3 Conditions for the maintenance of genetic equilibrium	
3. Elemental forces of evolution	**5**
3.1 Mutation	
3.2 Selection (types of selection, selection coefficient, selection in natural populations)	
3.3 Random genetic drift	
3.4 Migration	
4. Chromosomal, allozyme and DNA polymorphisms	**6**
4.1 Adaptive genetic polymorphism	
4.2 Balanced polymorphism and heterosis	
4.3 Genetic coadaptation and linkage disequilibrium	
5. Isolating mechanisms	**2**
6. Concepts of species and models of speciation:allopatric, sympatric and stasipatric	**3**
7. Phylogenetic relationships	**5**
7.1 Chromosome phylogeny in *Drosophila* (based on inversion polymorphism)	
7.2 Molecular phylogenies	
7.3 Neutral theory	
7.4 Molecular clock	

Section B: Parasitology

(Credit1)

	Hours of teaching
1. Parasites and parasitism	**1**
1.1 General consideration	
1.2 Type of parasites	
1.3 Type of hosts	
1.4 Symbiosis and commensalisms	
2. Molecular interaction between host and parasite and evasion of immunity	**2**
3. Protozoan parasites	**3**
3.1 Distribution, habit and habitat, structure, life cycle and diseases caused by	
3.1.1 *Entamoeba histolytica*	
3.1.2 *Leishmania donovani*	
4. Helminth parasites	**7**
4.1 General characters, organization and larval forms of Platyhelminthes and Nemathelminthes	
4.2 Distribution, habit and habitat, structure, life cycle and diseases caused by	
4.2.1 *Echinococcus granulosus*	
4.2.2 *Schistosoma haematobium*	
4.2.3 *Wuchereria bancroft*	

Books Recommended

Evolution

1. Dobzhansky: Genetics and the Origin of Species (1964, Columbia)

2. Dobzhansky: Evolution (1976, Surjeet Publ.

3. Freeman and Herron: Evolutionary Analysis (1998, Prentice Hall)
4. Futuyma: Evolutionary Biology (1998, Sinauer)
5. Hedrick: Genetics of populations (2005, Jones and Bartlett Publ Inc)
6. Hartl and Clark: Principles of Population Genetics (1989 & 1997, Sinauer)
7. Kimura: The Neutral Theory of Molecular Evolution (1984, Cambridge)
8. Li Wen-Hsiung and Dan Graur: Fundamentals of Molecular Evolution (1991, Sinauer)
9. Mayr: Animal Species and Evolution (1966, Belknap Press)
10. Ridley: Evolution (1993, Blackwell)
11. Strickberger: Evolution (2000, Jones and Bartlett)
12. White: Modes of Speciation (1978, Freeman)

Parasitology

1. Chatterjee: Parasitology(1981, Chatterjee Medical Publishers)
2. Chandler & Read: Introduction to Parasitology (1970, Wiley)
3. Marr *et al*: Molecular Medical Parasitology (2003, Elsevier)
4. Noble & Noble: Parasitology (1973, Lea & Febiger)
5. Smith: Animal Parasitology (1996, Cambridge University Press)

MAJOR ELECTIVES

ZOM 403A: BIOCHEMISTRY AND MOLECULAR BIOLOGY

Course IV: Regulation of Intermediary Metabolism
(Credit 3)

Hours of teaching

1. Intermediary metabolism and metabolic pathways **2**

2. Carbohydrate metabolic pathways, their integration and regulation **10**
- 2.1 Glycogenesis and glycogenolysis
- 2.2 Glycolysis and gluconeogenesis
- 2.3 Krebs cycle
- 2.4 Pentose phosphate pathway
- 2.5 Glyoxylate pathway

3. Lipids **11**
- 3.1 Fattyacid: biosynthesis and degradation
- 3.2 Cholesterol: biosynthesis and degradation
- 3.3 Lipid transport and storage
- 3.4 Eicosanoids: classification, biosynthesis and functions

4. Amino acids **10**
- 4.1 Amino acids as source for nitrogen
- 4.2 Synthesis and significane of polyamines
- 4.3 Amino acid catabolism
  - 4.3.1 Transamination
  - 4.3.2 Deamination: transdeamination and oxidative deamination
  - 4.3.3 Toxicity of ammonia
  - 4.3.4 Ammonia detoxification
  - 4.3.5 Urea cycle
    - 4.3.5.1 Reactions and their regulation
    - 4.3.5.2 Evolution of urea cycle

5. Nucleotides **6**
- 5.1 Biosynthesis and regulation of purine and pyrimidine nucleotides
- 5.2 Catabolism of purines and pyrimidines

Books Recommended

1. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2000, MacMillan Worth)

2. Berg et al: Biochemistry (5th ed2002, Freeman)
3. Mathews et al: Biochemistry (3rd ed 2004, Pearson)
4. Zubay et al: Principles in Biochemistry (2nd ed 1995, WCB)
5. Rawn: Biochemistry (1989, Neil Patterson)
6. Bender: Amino acid metabolism (1985, John Wiley)
7. Grisolia et al: The Urea Cycle (1976, John Wiley)
8. Voet & Voet: Biochemistry Vol I & II (3rd ed 2004, Wiley

ZOM 404A: BIOCHEMISTRY AND MOLECULAR BIOLOGY

Course V: Medical Biochemistry

(Credit-3)

	Hours of teaching
1. Biochemical basis of diseases/disorders, diagnosis and treatment	**2**
2. Molecular deficiency disorders	**7**
2.1 Enzyme deficiency: inborn errors of metabolism	
2.1.1 Alkaptonuria	
2.1.2 Phenylketonuria	
2.1.3 Lesh-Nyhan syndrome	
2.2 Protein defects/ deficiency	
2.2.1 Cystic fibrosis	
2.2.2 Sickel cell anaemia	
2.2.3 Thalassemia	
3. Transport/storage associated disorders	**5**
3.1 Hypercholesterolemia and atherosclerosis	
3.2 A-Beta-lipoproteinemia	
3.3 Tay-Sachs disease	
3.4 Gout	
4. Apoptosis and its implications in health and disease	**8**
4.1 Process of apoptosis	
4.1.1 Induction and biochemical changes	
4.1.2 Execution: cytochrome C release, caspase action	
4.1.3 Phagocytosis of apoptotic bodies	
4.2 Regulation of apoptosis: extra- and intra-cellular	
4.3 Implications	
4.3.1 Programmed cell death and development	
4.3.2 Development of immunological tolerance	
4..3.3 Neurological disorders	
5. Cancer	**4**
5.1. Biochemical aberrations	
5.2. Therapeutic srategies: TNF-alfa induced, immunological cytotoxicity, chemotherapy and radiotherapy	
6. Drug action, abuse and catabolism	**5**
6.1 Mechanisms	
6.2 Drug addiction, alcohol toxicity	
6.3 Catabolism of drugs	
7. Recent trends in therapy	**6**
7.1 Biomolecules as diagnostic markers and therapeutic agents	
7.2 Gene technology and gene therapy	
7.3 Drug delivery and targeting	
8. Medical gerontology	**2**

Books Recommended

1. Murray et al: Harper's Illustrated Biochemistry (27th ed 2006, McGraw Hill)
2. Ganong: Review of Medical Physiology (21st ed 2003, Lange Medical Publications)
3. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)
4. Goldsby et al: Immunology (5th ed 2003, Freeman)
5. Bhagvan: Medical Biochemistry (4th ed 2004, Hap)
6. Goodman et al: The Pharmacological Basis of Therapeutics (7th ed 1991, Macmillan Publishers)
7. Smith & Marks: Basic Medical Biochemistry (2nd ed 2005, LWW Lippincott's)
8. Chatterjea & Shinde: Medical Biochemistry (6th ed 2005, Jaypee brothers)
9. Bennett & Brown: Clinical Pharmacology (9th ed 2005, Elsevier)
10. Saini & Kaur: Clinical Biochemistry (1st ed 2001, CBS Publ)

11. Kanungo: Biochemistry of Aging (1980, Academic Press)
12. Kanungo: Genes and Aging (1994, Cambridge University Press)

ZOM 403B: ENTOMOLOGY
Course IV: Insect Physiology II
(Credit 3)

Hours of teaching

1. Endocrine organs and hormones **12**
- 1.1 Historical perspective
- 1.2 Endocrine glands and concept of neurosecretion
- 1.3 Biosynthesis and degradation of hormones
- 1.4 Function of JH and ecdysteroids
- 1.5 Mechanism of action of JH and ecdysteroids
- 1.6 Vertebrate hormones in insects
- 1.7 Eicosanoids and their functions

2. Nervous system: basic components and their function **2**

3. Neurotransmitters and neuromodulator system **8**
- 3.1 Cholinergic systems
- 3.2 Biogenic amines
  - 3.2.1 Synthesis and metabolism
  - 3.2.2 Catecholamines
  - 3.2.3 Indolamines
- 3.3 Amino acids
  - 3.3.1 Glutamatergic system
  - 3.3.2 GABAergic system
- 3.4 Neuropeptides
  - 3.4.1 FMRFamide-related peptides
  - 3.4.2 Cholecystokinin-related peptides
  - 3.4.3 Proctolin

4. Mechanisms for cuticular sclerotization **8**
- 4.1 Components of sclerotized cuticle (structural proteins, chitin, catechols, enzymes)
- 4.2 Dityrosine crosslinks
- 4.3 Quinone tanning
- 4.4 β-sclerotization
- 4.5 Differential mechanism of tanning
- 4.6 Combined pathway and cross linking mechanisms
- 4.7 Free radical formation

5. Visual system **2**
- 5.1 Compound eye
- 5.2 Image formation
- 5.3 Light and dark adaptation

6. Mechanism and significance of sound production **2**

7. Aerodynamics and the origin of insect flight **3**

8. Bioluminescence **3**
- 8.1 Light producing organs
- 8.2 Mechanism of light production
- 8.3 Control and significance of light production

ZOM 404B: ENTOMOLOGY
Course V: Agricultural Entomology
(Credit 3)

Hours of teaching

1. Insect – plant interactions **13**
- 1.1 Herbivory
  - 1.1.1 Leaf chewing

1.1.2 Plant mining and boring
1.1.3 Sap sucking
1.1.4 Gall formation
1.1.5 Seed predation
1.2 Insect feeding preference and host-plant selection
1.2.1 Role of plant chemicals in stimulation of feeding and oviposition
1.2.2 Role of plant chemicals as feeding deterrents
1.3 Plant toxins and their effect on insects
1.4 Insects and plant reproductive biology
1.4.1 Pollination
1.4.2 Myrmecochory
1.5 Host-plant resistance

2. Ground-dwelling insects **4**
2.1 Insects as scavengers
2.2 Insect-fungal interactions
2.2.1 Fungivorous insect
2.2.2 Fungus farming by leaf-cutter ants
2.2.3 Fungus cultivation by termites

3. Environmental monitoring using aquatic insects **1**

4. Insect pests of crops **17**
4.1 Major pests of the following crops, their life cycles, nature of damage caused and pest management: paddy, wheat, sugarcane, pulses, fibre crops, vegetables, fruits and stored grain
4.2 Polyphagous insect pest: locusts, termites, cutworms, gram pod borer, aphids

5. Environmental impact of insecticides **3**
5.1 Insect resistance to insecticides and resurgence
5.2 Effect on non-target animals

6. Forest entomology (insects damaging forest trees and their control) **1**

Books Recommended

1. Advances in Insect Physiology (vols. 1-28), Academic Press, 1986-2001
2. Alford: A textbook of Agricultural Entomology, Blackwell 1999
3. Atwal: Agricultural pests of India and South-East Asia, Kalyani Publishers, 1986
4. Blomquist et al.: Insect Pheromone Biochemistry and Molecular Biology: the synthesis and detection of pheromones and plant volatiles, Elsevier Acad. Press, 2003
5. Busvine: Insects and Hygiene (3rd ed.), Chapman and Hall, 1980
6. Byrd and Castner: Forensic Entomology, CRC Press, 2001
7. Chandler & Read: Introduction to Parasitology, Wiley International, 1970
8. Chapman: The Insects: Structure and Function (4th ed.), ELBS, 1998
9. Dhaliwal and Arora: Principals of Insect pest management, National Agricultural Technology Information Centre, Ludhiana, 1996
10. Dhaliwal and Arora: Trends in Agricultural Insect pest Management, Commonwealth Publ.,1994
11. Gilbert et al.: Comprehensive Molecular Insect Science (Volume 1- 7), Elsevier, 2005
12. Gillot: Entomology (2nd ed.) Plenum Press,1995
13. Gullan & Cranston: The Insects: An Outline of Entomology (2nd ed.) Blackwell, 2000
14. Gupta: Insect Hemocytes, Cambridge University Press, 1979
15. Harborne: Introduction to Ecological Biochemistry (4th ed.), 1993
16. Hill: Pest of stored foodstuffs and their control, Springer, 2002
17. Imms: A General Text Book of Entomology (2 vols.), Asia Publishing House, 1997
18. Kerkut and Gilbert: Comprehensive Insect Physiology, biochemistry and pharmacology (vols 1-13), Pergamon, 1985

19. Klowden: Physiological Systems in Insects, Academic Press, 2002
20. McGavin: Essential Entomology, Oxford Univ. Press, 2001
21. Metcalf and Flint: Destructive and useful insects and their control, McGraw Hill, 1962
22. Mullen and Durden: Medical and Veterinary Entomology, Academic Press, 2002
23. Norris et al: Concepts in Integrated Pest Management, Prentice-Hall, 2002
24. Pedigo: Entomology and Pest Management (4th ed.), Prentice Hall, 2002
25. Pruthi: A Text Book of Agricultural Entomology, ICAR, New Delhi, 1969
26. Purohit: Agricultural Biotechnology (2nd ed.) Agrobios (India), 2003
27. Racheigl and Racheigl: Biological and biotechnological control of insect pests, CRC Press, 1998
28. Rockstein: Biochemistry of Insects, Academic Press, 1978
29. Schoonhoven et al.: Insect-plant Biology- from physiology to evolution (1st ed.) Chapman & Hall, 1998
30. Srivastava: A Text Book of Applied Entomology (Vol. I & II, 2nd ed.) Kalyani Publ., 2001
31. Wigglesworth: Principles of Insect Physiology, ELBS, 1972

ZOM 403C: FISH BIOLOGY

Course IV: Capture Fishery

(Credit 3)

Hours of teaching

1. The inland capture fishery resources of India
- 1.1 Riverine fisheries
  - 1.1.1 Riverine fisheries resources — **1**
  - 1.1.2 Regulation and exploitation — **1**
  - 1.1.3 Improvement of fish stocks — **2**
  - 1.1.4 River pollution — **2**
  - 1.1.5 Dams and their effect on fish migration and remedial measures — **2**
- 1.2 Lacustrine fishery: management, development and exploitation — **3**
- 1.3 Cold water fishery: management, development and exploitation — **3**

2. Estuarine fisheries: management, development and exploitation — **3**

3. Marine fishery: exploitation of marine fishery resources of India — **4**

4. Chemical composition and nutritional value of fish — **4**

5. Fishery by-products, their production and utilization — **7**
- 5.1 Liver oils
- 5.2 Body oils
- 5.3 Fish meal
- 5.4 Fish flour
- 5.5 Fish silage
- 5.6 Fish solubles
- 5.7 Fish protein
- 5.8 Fish guano
- 5.9 Bone meal
- 5.10 Shark fins and fin rays
- 5.11 Fish roes
- 5.12 Fish glue
- 5.13 Isinglass
- 5.14 Fish skin
- 5.15 Chitin
- 5.16 Chitosan
- 5.17 Surgical suture from fish gut
- 5.18 Pearl essence
- 5.19 Surimi
- 5.20 Ambergris

6. Inland fishing gears and fishing methods — **3**

6.1 Biological factors in fishing
6.2 Types of fishing gears
6.3 Natural and synthetic fibres
6.4 Preparation and maintenance of fishing nets

7. Importance and methods of fish preservation **4**
7.1 Refrigeration and freezing
7.2 Drying
7.3 Salting
7.4 Smoking
7.5 Canning
7.6 Pickling, pasting and spicing
7.7 Fermentation
7.8 Marinating

ZOM 404C: FISH BIOLOGY

Course V: Fish Physiology II (based on teleosts)
(Credit 3)

Hours of teaching

1. Nervous system
1.1 Brain and cranial nerves **2**
1.2 Receptors
1.2.1 Eye **4**
1.2.1.1 Structure
1.2.1.2 Photoreceptive functions
1.2.1.3 Formation of image
1.2.1.4 Photoreception
1.2.1.5 Functional adaptations
1.2.2 Acoustico-lateralis system **3**
1.2.2.1 Labyrinth
1.2.2.2 Lateral line organs
1.2.3 Chemoreceptors **3**
1.2.3.1 Gustatory
1.2.3.2 Olfactory
1.2.4.3 Electroreceptors

2. Excretion and osmoregulation **7**
2.1 Glomerular and aglomerular kidneys
2.2 Excretion of nitrogenous wastes, water and ion balance
2.2.1 Urea cycle
2.2.2 Stenohaline teleosts
2.2.3 Euryhaline teleosts
2.2.4 Migratory teleosts

3. Endocrinology
3.1 Hypothalamo-hypophyseal system **4**
3.1.1 Neurosecretory system and neuro-hypophyseal hormones
3.2 Functional morphology of pituitary **3**
3.3 Hypothalamic control of pituitary **3**
3.4 Structure and functions of the following **8**
3.4.1 Thyroid
3.4.2 Ultimobranchials
3.4.3 Pancreas
3.4.4 Adrenal
3.4.5 Corpuscles of Stannius
3.4.6 Urophysis
3.4.7 Pineal

Books Recommended

1. Bentley: Comparative Vertebrate Endocrinology (2000, Cambridge University Press)
2. Bond: Biology of Fishes (1979, Saunders)
3. Brown: The Physiology of Fishes Vol I, II (1953 & 1957, Academic Press)

4. C.I.F.R.I.: Prawn Fisheries (Bulletin No. 10, 1977)
5. Chakroff: Freshwater Fish Pond Culture and Management (1987, Scientific Publishers)
6. Datta-Munshi & Hughes: Air-breathing fishes of India (1992, Oxford and IBH)
7. Davis: Culture and Diseases of Game Fishes (1956, University of California Press)
8. Duijn: Diseases of Fishes (1967, London Iliffe Books)
9. Evans: The Physiology of Fishes(1998, CRC Press)
10. Gopakumar, Singh and Chitranshi: Fifty Years of Fisheries Research in India (2000, Fisheries Division Indian Council of Agricultural Research)
11. Gorbman et al: Comparative Endocrinology (John Wiley)
12. Hadley: Endocrinology Prentice Hall (2000, International Editions)
13. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers)
14. Hoar & Randall: Fish Physiology, Series Vol. I – XIV (Academic Press)
15. Hora and Pillay: Handbook on Fish Culture in the Indo-Pacific Region (1962, Fisheries Division, Biology Branch,,FAO)
16. Howard & Churchill Canning technology (London)
17. Huet: Textbook of Fish Culture, Breeding and Cultivation of Fish, Fishing News (1989, Books)
18. Hughes: Comparative Physiology of Vertebrate Respiration, Heinemann Educational (1967, Books)
19. Jhingran: Fish and Fisheries of India (1985, Hindustan Publishing Corporation)
20. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
21. Kreuzer: Fishery products, FAO, Fishing News (1974, Books)
22. Kurian and Sebastian: Prawns and Prawn Fisheries of India (1976, Hindustan Publ)
23. Lagler: Studies in fresh water fishery biology (1950)
24. Lagler, Bardach, Miller and May Passino, Ichthyology (2003, John Wiley)
25. Mishra: Records of Indian Museum: an aid to the identification of the common commercial fishes of India and Pakistan Vol 5 (Part I-IV) (1962)
26. Nilsson & Holmgren: Fish Physiology Recent Advances (1986, Croom Helm)
27. Norman and Greenwood: A History of Fishes (3rd ed 1975, Ernest Benn)
28. Norris: Vertebrate Endocrinology (2nd ed 2007, Academic Press)
29. Proceedings of International Symposium on Reproductive Physioloy of fishes (1982, 1987, 1991, 1995, 1999.2003, 2007)
30. Ribelin & Migaki:The Pathology of Fishes(1975, The Univ. of Wisconsin Press)
31. Rounsfell and Everhart: Fishery Science: It's Methods and Applications (1985, John Wiley)
32. Santhanam: Fisheries Science (1990, Daya Publishing House)
33. Singh: Advances in Fish Research, Vol. I and II (1993 and 1997, Narendra Publishing House)
34. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)
35. Srivastava, Gopalji: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan)
36. The Wealth of India, Raw Materials Vol IV Fish and Fisheries (1962, CSIR)
37. Pillay: Aquaculture: Principles and Practices: Fishing News Books: (2005, First Indian reprint)
38 .Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, Chand)

ZOM 403D: MOLECULAR ENDOCRINOLOGY AND REPRODUCTIVE PHYSIOLOGY

Course IV: Hormone Receptors, and Signaling Mechanisms

(Credit 3)

Hours of teaching

1. Control of hormone secretion **7**

1.1 Synthesis, processing, and sorting of preprohormone precursor
1.2 Sequential stages of the regulated secretory pathway
1.3 Dense-cored granule exocytosis
1.4 Regulation of exocytosis by calcium and protein kinase C

2. Receptors **7**

2.1 Nuclear receptors
2.1.1 Structure
2.1.2 Families (glucocorticoid, thyroid and estrogen)
2.1.3 Metabolism
2.1.4 Activation and recycling
2.2 Membrane receptors

2.2.1 Enzyme-linked receptors
2.2.2 Cytokine receptors
2.2.3 G-Protein coupled receptors
2.2.4 Ligand-gated ion channels

2.3 Hormone signaling **12**
2.3.1 Receptor tyrosine kinase pathway
2.3.2 Cytokine receptors pathway
2.3.3 Cyclic AMP pathway
2.3.4 Phospholipid/calcium- protein kinase C pathway
2.3.5 Nitric oxide signaling pathway
2.3.6 MAP kinase pathway

2.4. Hormonal control of gene expression **4**

3. Molecular basis of hormone synergism and antagonism **4**
3.1 Glycogen metabolism
3.2 Smooth muscle contraction

4. Termination of hormone action **1**

5. Pathophysiology of hormone receptors, hormone analogues as drug and xeno-estrogens **4**

Books recommended

1. Bolander: Molecular Endocrinology (3rd ed 2006, Elsevier)
2. DeGroot and Jameson: Endocrinology, Vol 1 (5th ed 2006 Saunders)
3. Larson: Williams Textbook of Endocrinology, 10th ed 2002, Saunders)
4. Alberts et al: Molecular Biology of the Cell(4th ed 2002, Garland)
5. Squires: Applied Animal Endocrinology (2003, CABI publications)

ZOM 404D: MOLECULAR ENDOCRINOLOGY AND REPRODUCTIVE PHYSIOLOGY

Course V: Fertility and Sterility

(Credit-3)

Hours of teaching

1. Control of male fertility **9**
1.1 Chemical interference
1.1.1 Suppression of spermatogenesis
1.1.1.1 Suppression of hypophysial activity by steroid hormones
1.1.1.2 Chemicals acting directly on the testis
1.1.2 Prevention of sperm maturation in epididymis
1.2 Immunological interference
1.3 Surgical interference with reference to vasectomy

2. Control of female fertility **9**
2.1 Inhibition of ovulation with reference to oral contraceptives
2.2 Mechanical methods with reference to intrauterine devices
2.3 Immunological approaches

3. Male sterility **5**
3.1 Parameters of male sterility
3.2 Origin and cause of male sterility
3.2.1 Azoospermia
3.2.2 Oligozoospermia
3.2.3 Varicocoele
3.2.4 Cryptorchidism

4. Female sterility **5**
4.1 Tubal factors
4.2 Premature ovarian failure
4.3 Polycystic ovarian syndrome
4.4 Luteal insufficiency
4.5 Endometriosis

5. Assisted reproductive techniques (ART) **5**
5.1 Principles of ART and protocols

5.2 Types of ART
5.3 Cryopreservation of gametes

6. Primer pheromones **6**
6.1 Estrous cycle disruption
6.2 Male induction of estrus (Whitten effect)
6.3 Male induced pregnancy block (Bruce effect)
6.4 Pheromones and puberty
6.5 Human reproductive pheromones

Books Recommended (Courses II, III and V)

1. Leung and Adashi: The Ovary (2004, Raven Press)
2. Adashi et al: Reproductive Endocrinology, Surgery and Technology (1996, Lippincott- Raven publishers)
3. Findlay: Molecular Biology of the Female Reproductive System (1994, Academic Press)
4. Knobil & Neill: The Physiology of Reproduction, Vol. I & II (1994 Raven Press)
5. Knobil & Neill: Encyclopedia of reproduction, Vol. 1-4, Academic Press, 1998.
6. Lamming: Marshall's Physiology of Reproduction (1984, Longman)
7. Mann & Lutwak-Mann: The Male Reproductive Function and Semen (1998, Springer)
8. Paulson et al: Andrology: Male Fertility and Sterility (1986, Academic Press)
9. Setchell: The Mammalian Testis (1992, Cornell University Press)
10. Yen et al: Reproductive Endocrinology (1999, Saunders)

ZOM 403E: MOLECULAR AND HUMAN GENETICS

Course IV: Clinical Genetics

(Credit 3)

Hours of teaching

1. History, nature and frequency of genetic diseases

2. Molecular and biochemical basis of genetic diseases **14**
2.1 Monogenic disorders
2.1.1 Autosomal (cystic fibrosis, thalassaemias, Charcot-Marie-Tooth syndrome)
2.1.2 X-linked (hemophilia A, Duchenne muscular dystrophy, color blindness)
2.2 Metabolic disorders (phenylketonuria, polysaccharidosis)
2.3 Genomic disorders (neurofibromatosis-1)
2.4 Dynamic mutations (Huntington disease)
2.5 Late onset disorders (Alzheimer disease)
2.6 Imprinting disorders (Prader-Willi syndrome, Angelman syndrome)
2.7 Mitochondrial diseases (MELAS)

3. Multifactorial diseases: atherosclerosis, diabetes mellitus

4. Clinical cytogenetics **9**
4.1 Cytogenetic techniques in disease detection
4.2 Chromosomal anomaly and clinical phenotypes
4.3 Aneuploidy in human disease: autosomal, sex-chromosomal, aneuploidy and parental age
4.4 Chromosomal deletions
4.5 Microdeletion syndromes
4.6 Structural rearrangements in chromosomes
4.7 Fetal wastage and chromosomal anomalies

5. Management of genetic disorders **5**
5.1Treatment of metabolic disorders
5.2 Replacement therapy
5.3 Gene therapy
5.3.1 Somatic versus germ line
5.3.2 *Ex vivo* and *in vivo* gene therapy
5.3.3 Gene therapy strategies and gene delivery vehicles
5.3.4 Clinical applications
5.3.5 DNA vaccines

5.4 Stem cell therapy

6. Genetic counseling

6

6.1 Concept and purpose
6.2 Risk evaluation
6.3 Diagnostics (chromosomal, post-natal, pre-natal, pre-implantation, pre-fertilization)
6.4 Population screening
6.5 Legal and ethical considerations

ZOM 404E: MOLECULAR AND HUMAN GENETICS

Course V: DNA Repair and Recombination, Cancer Genetics and Immunogenetics
(Credit 3)

Hours of teaching

Section A: DNA repair and recombination (Credit 1)

1. DNA damage and repair **6**

1.1 Endogenous and exogenous sources, types of DNA damage
1.2 Repair pathways in pro- and eukaryotes, damage specificity
1.3 Damage signaling and checkpoints
1.4 DNA repair-associated disorders

2. Recombination **7**

2.1 Homologous recombination
2.2 Mechanism of recombination in bacteria and mammals
2.3 Gene conversion
2.4 Site-specific recombination
2.5 Transpositional recombination
2.6 Mitotic recombination
2.7 Recombination and genomic instability
2.8 Application in genetic engineering

Section B: Cancer Genetics (Credit 1)

1. Genetic regulation of cell cycle and apoptosis **2**

2. Cell transformation and tumorigenesis **8**

2.1Oncogenes
2.2 Tumour suppressor genes
2.3 DNA repair genes and genomic instability
2.4 Epigenetic modifications, telomerase activity, centrosome malfunction
2.5 Genetic heterogeneity and clonal evolution

3. Genetic models for familial cancer: retinoblastoma, colorectal cancer, breast cancer1

4. Tumor progression: angiogenesis, metastasis **1**

5. Tumor-specific chromosome rearrangements, tumor specific markers **1**

Section C: Immunogenetics (Credit 1)

1. Immune response proteins: genetic basis of structure and diversity **1**

2. Immunoglobulin gene superfamily **9**

2.1 Organization of Ig gene loci
2.2 Genetic basis of antibody diversity
    2.2.1 Somatic recombination: V(D)J recombination and junctional diversity
    2.2.2 Somatic hypermutation
    2.2.3 Allelic exclusion
    2.2.4 Class switching
2.3 Organization of TCR gene loci and genetic basis of TCR diversity
2.4 Organization of HLA locus: genetic polymorphism and HLA haplotypes

3. Immune disorders **3**

3.1 Primary and secondary immunodeficiency disorders
3.2 HLA and disease association

Books Recommended

1. Alberts et al, Molecular Biology of the Cell (4th ed 2002, Garland)
2. Baker et al: A Guide to Genetic Counseling(1998, Wiley)
3. Bate & Arias: The Development of *Drosophila melanogaster*, vols 1-2 (1993 CSHL Press)
4. Brooker: Genetics- Analysis and Principles, Benjamin
5. Brown, Gene Cloning (3rd ed 1995, Stanley)
6. Brown, Genomes (3rd ed 2007, Bios)
7. Connors & Smith: Essentials of Medical Genetics (3rd ed, Blackwell)
8. Cowell, Molecular Genetics of Cancer (2nd ed, Eaton)
9. Cox & Sinclair: Molecular Biology in Medicine (1996, Blackwell)
10. Davies: Human Genetic Disease Analysis (Saunders)
11. Ehrlich, DNA Alterations in Cancer (Eaton)
12. Emery & Mueller: Elements of Medical Genetics (ELBS)
13. Fairbanks et al: Genetics: The Continuity of Life
14. Gersen & Keagle: Principles of Clinical Cytogenetics (Humana)
15. Gibson & Muse: A Primer of Genome Science (2002, Sinauer)
16. Gilbert: Developmental Biology (8th ed 2006, Sinauer)
18. Glick & Pasternak: Molecular Biotechnology (2nd ed ,ASM Press)
19. Goldsby et al: Kuby Immunology (Mosby)
20. Gregory (ed): The Evolution of the Genome (2006, Elsevier)
21. Hartl & Jones: Genetics: Principles & Analysis of Genes & Genomes(2001, Jones & Bartlett)
22. Hartl: Essential Genetics: A Genomic Perspective (3rd ed, Jones Blackett)
23. Hawley & Walker: Advanced Genetic Analysis (Blackwell)
24. Howley & Mori: The Human Genome (AP)
25. Jorde et al: Medical Genetics (3rd ed, Elsevier)
26. Korf: Human Genetics: A Problem Based Approach (1997, Blackwell)
27. Lindahl & West: DNA repair & Recombination (Chapman)
28. Lewin: Genes IX (2008, Jones & Barlett)
29. Lewis: Human Genetics (3rd ed, WCB McGraw)
30 Lodish et al: Molecular Cell Biology (4th ed 2008, Freeman)
31. Mange and Mange: Basic Human Genetics (1999 Sinauer)
32. Nickoloff & Hoekstra (ed): DNA Damage and Repair, vol II (2001, Humana)
33. Nussbaum et al: Genetics in Medicine (Saunders)
34. Passarge: Colour Atlas of Genetics (2nd ed, Thieme)
35. Pasternak: An Introduction to Human Molecular Genetics (2005, Wiley
36. Primrose & Twyman: Principles of Genome Analysis and Genomics (Fritzgerald)
37. Rimoin et al: Principles & Practice of Medical Genetics, vols I-III (5th ed 2007, Churchill Livingstone)
38. Robinson & Linden: Clinical Genetics handbook (Blackwell)
39. Roit et al: Immunology (Mosby)
40. Rooney: Human Cytogenetics (3rd ed, Oxford)
41. Sambrook et al: Molecular Cloning, vols 1-3 (3rd ed, CSHL Press)
42. Snustad and Simmons: Principles of Genetics (4th ed 2006, Wiley)
43. Stillman: Molecular Genetics of Cancer (CSHL Press)
44. Strachan & Read: Human Molecular Genetics (2004, Wiley)
45. Sudbery: Human Molecular Genetics (2nd ed 2002, Prentice Hall)
46. Vogel & Motulsky: Human Genetics (3rd ed, Springer)
47. Watson et al: Molecular Biology of the Gene (5th ed 2004, Pearson Education)
48. Wilson: Clinical Genetics: A Short Course (Wiley)
49. Wolpert: Principles of development (2nd ed 2002, Oxford)
50. Young: Introduction to Risk Calculation in Genetic Counseling (2nd ed, Oxford)
51. Phadke: Genetics for Clinicians (2007, Prism)
52. Kumar: Genetic Disorders in Indian Subcontinent (2004, Kluwer)

LABORATORY EXERCISES

ZOM 405: ANIMAL BEHAVIOUR & ENVIRONMENTAL BIOLOGY AND EVOLUTION & PARASITOLOGY

Part A: Animal Behaviour and Environmental Biology
(Credit 1.5)

Animal Behaviour

1. Study of dominant-subordinate relationships in male mice
2. Study of courtship behaviour in *Drosophila melanogaster*
3. Study of habitat selection in spiders or larvae of *Drosophila melanogaster* or woodlice
4. Study of learning behaviour in mice by using a zigzag or T-shaped maze
5. Study of wall-seeking behaviour in mice
6. A field study of play behaviour or parent-young interactions in a troop of rhesus monkeys,*Macaca mulatta*
7. A field study of foraging or trail making behaviour in a seed harvester or predatory ant species
8. A field study of flower choice or colour perception in bees

Environmental Biology

1. Determination of standing crop energy status in a grassland area and construction of 'number'and 'biomass (wet weight) pyramids
2. Study of biotic components of a terrestrial ecosystem and description of the morphological adaptations of the collected organisms
3. Study of biotic components of a pond ecosystem and description of morphological adaptations of the collected organisms
4. Estimation of autotrophs in a terrestrial ecosystem
   4.1 Frequency of different species
   4.2 Abundance of species in the community
   4.3 Density of different species in the community by quadrat method
5. Estimation of heterotrophs in a terrestrial ecosystem
   5.1 Frequencies of different species
   5.2 Abundance of species in the community
   5.3 Density of different species in the community by quadrat method
6. Determination of texture, pH, carbonate, nitrate and base deficiency in different soil samples
7. Measurement of chlorophyll content per unit area of a grass field
8. Estimation of grasshopper population density of an area by capture-recapture method
9. Measurement of oxygen change and productivity differences in a pond ecosystem by Winkler's method

Part B: Evolution & Parasitology
(Credit 1.5)

Evolution

1. Study of quantitative inheritance in *Drosophila*: sternopleural bristle phenotypes in *D. melanogaster*
2. Demonstration of natural selection under laboratory conditions by making competition between red-eyed and white-eyed *D. melanogaster*
3. Demonstration of Hardy-Weinberg equilibrium in human populations by taking examples of MN and ABO blood group systems
4. Study of inversion polymorphism in *Drosophila*
5. Study of sexual isolation between two closely related and sympatric species of *Drosophila* : *D. bipectinata* and *D. malerkotliana*

Parasitology

1. Collection, fixation and permanent stained preparation of rectal ciliates
2. Study of different protozoan parasites using permanent slides
3. Collection, fixation and permanent stained preparation of helminth parasites of goat rumen
4. Study of various larval stages in the life cycle of digenetic trematodes
5. Study of the following using permanent slides
   5.1 Trematode
   5.2 Cestode

5.3 Nematode

MAJOR ELECTIVE LABORATORY EXERCISES

ZOM 406A: BIOCHEMISTRY AND MOLECULAR BIOLOGY

Course II (Credit 2)

Part A: Regulation of Intermediary Metabolism (Credit 1)

1. Effect of starvation on liver glycogen content in rat/mouse
2. Estimation of blood glucose level using glucose oxidase method
3. Estimation of total cholesterol, HDL-cholesterol and triacyl glycerol
4. Estimation of amino acid concentration
5. Assay of adenine deaminase (ADA) in rat/mouse tissues

Part B: Medical Biochemistry (Credit 1)

1. Study of pathological condition in rat/mouse model: liver cirrhosis, diabetes and ascites tumor
2. Analysis of enzymatic/biochemical markers from serum/tissues of rat/mouse model
   - 2.1 Studies on the anti-oxidant enzymes (SOD, catalase and GPx) in normal and diseased rats
   - 2.2 Native-PAGE analysis of LDH isoforms
   - 2.3 Spectrophotometric assay of SGOT (AST) and SGPT (ALT)
   - 2.4 Estimation of bilirubin concentration
   - 2.5 Electrophoretic analysis of lipoproteins
3. Study of apoptosis in liver cirrhotic/tumor model
   - 3.1 Analysis of DNA-degradation pattern using agarose gel electrophoresis
   - 3.2 Western blot analysis of release of cytochromeC from mitochondria
   - 3.3 Expression analysis of Bcl2 and pro-apoptotic factors (Caspase3 and 9)
4. Demonstration of expression of a gene/protein during aging

ZOM 406B: ENTOMOLOGY

Course II (Credit 2)

Part A: Insect Physiology II

1. Dissection of CNS of *Dysdercus* and cockroach.
2. Whole mount stained preparation of
   - 2.1 Brain
   - 2.2 Corpora cardiaca
   - 2.3 Corpora allata
   - 2.4 Prothoracic gland
3. Preparation of histological slides of brain, corpus cardiacum, corpus allatum and CNS ganglia
4. Preparation of permanent AF stained slide to demonstrate presence of MNSCs in brain of cockroach/ *Dysdercus*
5. To observe the effect of insect hormones (JH, 20-E, etc.) on the growth and development of *Dysdercus*/silkworm
6. Demonstration of presence of chitin in the cuticle of cockroach
7. Dissection of lamina medulla lobula complex in live cockroach/cricket
8. Ligation experiment to demonstrate effect of brain hormones on development
9. Lipids detection by TLC in hemolymph

PART B: Agricultural Entomology

1. Identification of insects belonging to economically important insect orders (Orthoptera, Hemiptera, Lepidoptera, Hymenoptera, Diptera) using couplet keys
2. Dissection and permanent whole mount preparation of
   - 2.1 Mouthparts of cockroach and *Dysdercus*
   - 2.2 Mouth parts and legs of honey bee
3. Study of insect pests of stored grains
4. Study of food preference of grasshoppers and *Tribolium* sp. / *Callosobruches* sp.
5. Study of repellents on stored grain pests using an olfactometer

6. A field study of the insect pests of pulses or vegetables
7. A field study of aquatic insects
8. Culture of *Dysdercus*
9. Study of systemic effect of Rogor on *Dysdercus*

ZOM 406C: FISH BIOLOGY
Course II (Credit 2)
Part A: Capture Fishery

1. Study of efficacy of different methods (freezing, drying, salting, and salting and drying simultaneously) of fish preservation
2. Determination of protein and lipid contents in fresh and preserved fishes (carp and catfish)
3. Periodic survey of fish market to collect gonads and data related to length weight relationship
4. Visit to a fishing site to study the variety of fish catches at different seasons
5. Study of fishing nets being used at different seasons

Part B: Fish Physiology II (based on teleosts)

1. Preparation of permanent stained slides of different endocrine glands and kidney of *Heteropneustes fossilis* or *Clarias batrachus*
2. Survey of different endocrine glands
3. Dissection and display of cranial nerves of Mystus
4. Surgical ablation of pineal gland and gonads in a live fish

ZOM 406D: MOLECULAR ENDOCRINOLOGY AND REPRODUCTIVE PHYSIOLOSY
Course II (Credits 2)

Part A: Hormone Receptors and Signaling Mechanisms

1. Demonstration of exocytotic cycle by electronmicrographs
2. Demonstration of gonadotropin receptors/ growth factors in the ovary by western blot
3. Demonstration of receptor assay
4. Estrogen bioassay in female rat
5. Demonstration of estrogenic activity in certain plant products
6. Biochemical estimation of nitric oxide by nitrate/nitrite assay
7. Effect of glucagon and insulin on liver glucose
8. Effect of hormones on lipid metabolism

Part B: Fertility and Sterility

1. Operations in rat
   1.1 Induction of cryptorchidism
   1.2 Vasectomy
   1.3 Tubectomy
   1.4 Hysterectomy
2. Study of sperm motility, sperm morphology, and sperm count in rat
3. Effect of cadmium chloride treatment on testis
4. Effect of anti-androgens on sperm storage in epididymis
5. Induction of superovulation in mouse/rat
6. Induction of PCOS condition in rat
7. Demonstration of *in vitro* sperm-egg interaction
8. Demonstration of GVBD in oocyte
9. Demonstration of the Whitten and Lee-Boot effects in cycling mice
10. Biochemical estimation of succinate dehydrogenase and catalase activity
11. Kymographic demonstration of uterine contraction under different experimental conditions (Dale′s apparatus recording)

ZOM 406E: MOLECULAR AND HUMAN GENETICS
Course II (Credit 2)
Part A: Clinical Genetics

1. Chromosome preparations from cultured human lymphocytes
2. Preparation of karyotype and idiogram from G-banded metaphases and annotations of the bands
3. Familiarity with characteristic features of human chromosomal disorders

4. Detection of Downs syndrome by analysis of chromosomes
5. ARMS test for detection of thalassaemia
6. Multiplex based detection of DMD
7. Detection of microdeletion of Y-chromosome in cases of male infertility
8. Detection of trisomy 21 by fluorescence *in situ* hybridization

Part B: DNA Repair and Recombination, Cancer Genetics and Immunogenetics

1. Study of sister chromatid exchanges (basal and induced) in cultured human lymphocytes
2. Study of chromosomal aberrations
3. Study of micronuclei in cultured human lymphocytes (control and induced)
4. Estimation of DNA damage by comet assay (demonstration)
5. Induction of mutation in *Drosophila* and detection by attached-X or Muller-5 method
6. Detection of Philadelphia chromosome in CML cells
7. Detection of human papilloma virus in cervix cancer
8. Immunostaining
9. Raising antibodies in rabbit/mouse using a suitable antigen

ZOM 407(A-E): Project work/ Dissertation
(Credit 4)

Topic will be based on Major elective opted by the students. Project will include laboratory based work. Project report to be submitted and presented including viva voce.

ZOM 408: Seminar
(Credit 1)

On a current topic within 45 minutes to be evaluated by a panel of examiners.