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

(If the number of candidates in the paper is less than 20)

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 /	X	0

Dissertation / Training		

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) <u>End Semester Examination and evaluation (for 70 marks):</u>

(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) <u>Admit Card (for End Semester Examinations):</u>

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. <u>PROMOTION RULES AND SUPPLEMENTARY EXAMINATION</u>

1. <u>2-YEAR M.Sc. (FOUR SEMESTER) PROGRAMMES</u>

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) <u>*First Semester Course & Examination:*</u>

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 Ist, 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, 6th 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.

Aerial Photo Interpretation and GIS

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.