CURRICULA AND SYLLABI

- M.Sc. (2yr & 5yr)
- M.A.
- M.B.A.




www.nitrkl.ac.in

PREAMBLE

The curriculum of an institution of higher learning is a living entity. It evolves with time; it reflects the ever changing needs of the society and keeps pace with the growing talent of the students and the faculty. The curriculum of the MSc, MA and MBA programmes of NIT Rourkela is no exception. Half a century of experience in preparing graduates in engineering and postgraduates in science for a wide variety of industries has led to creation of the new curriculum. I sincerely believe that it will meet the aspirations of all stake holders – students, faculty and the employers of the graduates and postgraduates of NIT Rourkela.

In the old college – university system the curricula and syllabi represented the upper limit of the material to be covered, the teacher having no motivation for stepping outside the defined territory. In the autonomous institute system, the curriculum and syllabi only serve as a guideline. The teacher enjoys freedom to expand it in any direction he feels appropriate, incorporates his latest knowledge and stimulates the creative minds of the students. He experiments with new contents and new techniques. A new teaching-learning paradigm is born.

This book of curricula is the culmination of the efforts of large number of faculty members and supporting staff. It also reflects the creative contribution of hundreds of teachers – both serving and retired, over the past five decades. In keeping with the demands of the changing times, it contains many innovative features. The introductory sections of the book highlight the special features of the NIT Rourkela PG curriculum. I sincerely hope that the faculty and students of NIT Rourkela will take full advantage of the dynamic features of the curriculum and make the teaching-learning process a truly sublime experience for all.

On behalf of the Senate of NIT Rourkela, I record my appreciation of the meticulous work done by the colleagues for bringing out this book. I also record my personal gratitude to the members of the Senate who have lent every bit of their wisdom to make the contents truly superior.

Sunil Kr Sarangi

CONTENTS

A. PHILOSOPHY OF THE CURRICULUM

Like most institutions of higher learning, the teaching-learning process of NIT Rourkela is expressed in terms of course credits, one credit being approximately equal to 1 hour of lecture class or 1.5 hours of laboratory or design class per week. M.A, M.Sc and MBA programms are expected to little over 100 credits distributed over four.

The postgraduate curriculum of NIT Rourkela has strived to offer both theory courses as well as laboratory and design practice in all major areas of study. It has, however, consciously avoided combining theory and laboratory classes in the same course (e.g. L-T-P = 3-0-3). It was felt that an inflexible combination of theory and laboratory components will limit the opportunity to study a wider variety of subjects and increase failure rate. Instead, the NITR system offers separate courses for theory and laboratory components in the form of (3-0-0) or (3-1-0) theory courses and (0-0-3) laboratory courses. In order to make the time table simple and easily implementable, the variety of course volume has been limited to only three types – (0-0-3) 2 credits, (3-1-0) 4 credits and (0-0-0) 2, 4, 20 credits. Teachers are expected to package appropriate volume of teaching material in a subject to justify one of these three modes.

Semesters

	I	II	III	IV	Total	
Theory	5	5	4	4	18	60
Laboratory	4	4	3	3		28
Others	-	-	SIRE – 2 STW – 2 Project – 4	Comp Viva – 2 STW – 2 Project – 6		18

	Core	PE	OE
Theory 18	8	6	4

(Guidelines) Lab Laboratory — Minimum 6 in Experimental Laboratory or Software

Practical/Design Courses

Type of Course	No. of Courses	Credits
Professional Laboratory Courses:	4	8
Total:	**4**	**8**

NIT Rourkela curriculum has certain innovative features that are rather uncommon in traditional universities and institutes in India. Among them are:

(1) Special Topic in <specialization name> [Course Nos.: AA 681 and AA 682, AA standing for the Department code]. While for a normal subject, the syllabus needs to be approved by the Senate and notified in advance, the syllabus of a special topic shall be approved by the Departmental Academic Committee of the offering department and reported to the Senate at its earliest meeting. The contents may change semester to semester and multiple instances may be floated in a single semester. A student, may however, register for maximum one special topic in an odd semester (AA 681) and another in an even semester (AA 682). Such courses give opportunity to departments to convert new ideas of existing faculty, expertise of new and visiting faculty, suggestions of employers etc. to tangible courses without waiting for prior approval of the Senate. It is expected that if a course is offered as a special topic and is expected to continue, the department will take steps to introduce a formal course on the subject with approval of the Senate.

(2) Special Laboratory in <specialization name> [Course Nos.: AA 683 and AA 684:] Similar to special topics AA 681 and AA 682 except that the latter are for theory courses, while the special laboratories cover practical, design and CAD courses.

(3) Research Project I & II [AA 591 and AA 592 (M.Sc)], [AA 693 and AA 694 (M.Tech)]: Postgraduate research is receiving increasing emphasis in institutions of higher learning. It is an important component of NIT Rourkela's curriculum. The total credits in M.Tech shall be 40 which may be split as 20+20 as per the department. Other details are given in the regulations.

Postgraduate projects also constitute important components of the R&D programmes of the departments. Students carry out the research ideas of their supervisors, and in the process learn the techniques of research. It is essential that they become proficient on computer assisted literature search, patent search, experimental and computational techniques, systematic recording of data, writing of thesis and presentation before a scholastic audience. Needless to say, original scientific concepts and their effective exploration shall get due credit in evaluation of the projects.

Normally, thesis evaluation shall be based on 3 components – (a) evaluation by supervisor based on day to day work by the student, (b) that by departmental committees that will lay emphasis on proper research methodology and maintenance of records, and (c) that by institute level committees which will strive to ensure that students have demonstrated effective use of institutional resources such as computer aided literature search, patent search, use of advanced fabrication and characterization equipment, industrially relevant R&D problems and the like that bring glory to the institute. The Senate, at its discretion, may delegate this responsibility to the department concerned or to a committee of teachers.

Barring exceptional cases, the grade awarded in the "Research Project" courses shall not be below 'C'. To qualify for 'C' or higher grade, a student will be given additional time in units of one month. Till the project is re-evaluated the student will be given as 'I' grade in official records.

All theses of NIT Rourkela shall be made available to scientific workers around the globe. Any dishonest practice or plagiarism will lead to severe academic penalty to the student and appropriate administrative steps against the supervisors. The Project record book shall be the key element of the exercise. Continuous discussions and signatures by supervisors on the record book, and faithful reproduction of record books on the thesis will ensure an honest scholastic environment in the Institute.

(4) Seminar & Technical Writing [AA 685 to AA 688 (M.Tech)]: These subjects are introduced in the first year and final year of M. Tech. and the courses of [AA 593, AA 594] in M. Sc. Courses to:

(a) give students exposure to variety of topics through the medium of attending seminars, and

(b) teach them the skill of writing technical articles, concepts of abstract, Introduction, material and methods, conclusion, references, acknowledgement etc.

The students shall not be required to present seminars; they will attend seminars presented by others, as per recommendation of the teacher. These will include seminars by faculty and research students in the department and by invited experts in the same or related departments. Every student will be required to write a brief (1/2 page) report on what he learnt in the seminar. The technical writing shall cover writing of scientific articles on any subject chosen jointly by the student and the teacher. The article may be presented either as a printed document, a poster, a recorded video/audio presentation or as combinations of more than one media.

In a semester, a student shall be required to attend 6 – 10 seminars and write 2 scientific (including popular science) articles or posters. The record books, articles and posters will be on display in departmental libraries, web sites or in any other media for public benefit. Copies shall be made freely available on demand. The teacher will announce his plan of activities at the beginning of the semester and make it continuously available to students through the institute's intranet site.

Evaluation shall normally be made solely by the teacher, but may be moderated by committees appointed by the Senate as per Institute rules.

(5) Short Term Industrial / Research Experience (SIRE) [AA 595 (M.Sc)] and Summer Research / Industrial Project [AA 691 (M.Tech)]

Summer industrial training has been a part of engineering education for a long time. NIT Rourkela insists on an eight week summer internship either in industry or in an R&D organization, including educational institutes with excellent research culture. The student is expected to submit a formal report at the end of the programme. This requirement is applicable to both M.Tech and M.Sc students. In exceptional cases, a project may be carried out within the Institute; but that is discouraged.

(6) Comprehensive Viva-Voce [AA 596 (M.Sc), AA 692 (M.Tech)]

Postgraduates of NIT study many theory and laboratory courses, while resource constraints force the Institute to adopt a credit and subject based curriculum. It appreciates the value of holistic learning. The comprehensive viva-voce aims to test the holistic comprehension of the student covering all the subjects taught. The questions in the oral examination will, generally, be such as to use contents of two or more subjects for framing an answer.

(7) Emphasis on Quantitative Approach

Quantitative analysis is often considered the corner stone of engineering education. In fact, in our country, universities often offer both M.Tech. and M.Sc. degree in the same subject such as Biotechnology, Materials Science and Electronics, the distinction between the two streams being the degree of quantitative and numerical approach. All branches of engineering shall make a conscious effort to introduce quantitative analysis and numerical problem solving in most theory papers. Examination questions will also reflect this spirit. Basic science courses offered to engineering students will also inculcate the quantitative approach.

(8) Use of Computers and Modern Educational Technology Tools

The faculty shall make a conscious effort to exploit the massive computational and data handling capacity of modern day computers (hardware and software) and related devices. They will specifically include equation solving tools (e.g. EES, MALTAB), simulation software etc. Technology Enhanced Learning may be used in theory subjects, design courses, laboratories, projects, examination and evaluation. Innovative and creative approaches shall, in general, be encouraged as long as they do not compromise on academic standards.

(9) Multi-Disciplinary Approach

Unlike our counterparts in developed countries, many colleges and universities in India draw a bold line between science and engineering. At NIT Rourkela, while the line is quite bold at organization level, it almost vanishes in research and teaching. There is no distinction between courses offered by Science and Engineering Departments; a student can take courses from any department oblivious of its character, as long as he is within the curricular constraints prescribed by the department.

(10) Maintenance of Curricular Standards

Creating an ambitious curriculum is one thing, but following the prescriptions is another. In a scholastic environment, it is neither feasible nor desirable to have a policing system imposed from outside. Compliance to curricular requirements must be voluntary, at best dictated by peer pressure. Faculty students, technicians and the administration — all are stake holders. The Senate, the ultimate guardian of academic standards shall monitor compliance by the faculty and students. There will be an Academic Programme Monitoring Committee which will routinely examine the activities in the departments and report to the Senate. It will also give suggestions for continuous improvement of standards and greater compliance by all concerned.

Occasionally the Senate may prescribe repetition of a curricular activity or additional work to compensate for activities not done. Such prescriptions shall be binding on all – faculty, students and technicians. Stake holders who silently encouraged missed classes or similar failures without drawing attention of concerned authorities should gladly accept such

additional assignment. The best way, however, will be to maintain high standards as a matter of habit.

1. EXCERPTS FROM REGULATIONS

The M.Tech, M.Sc, MA and MBA Programme of NIT Rourkela are governed by the undergraduate regulations approved by the Senate and the Board of Governor as. In this chapter, some important sections of this document are reproduced for ready reference by the students and the faculty. Students are advised to consult the original book of regulations and amendments issued from time to time for complete guidance. This section and subsections numbers given in this chapter refers to the corresponding section numbers in the original document.

Academic Calendar

1.1 The academic session is -divided into two semesters each of approximately 17 weeks duration: An Autumn / Odd semester (July - November) and a Spring / Even semester (January - May). In addition, a summer session (May - July) may be offered at the discretion of the Senate under special circumstances.

1.2 The candidates have to take admission to the institute on the dates as per Academic Calendar approved by the Senate. Under special circumstances, e.g. foreign students nominated by the Government of India or a serious medical illness, the Senate (or Chairman Senate on its behalf) may condone delay up to one month from the starting of classes.

1.3 The Senate will approve the academic calendar consisting of schedule of activities for a session inclusive of dates for registration, Mid semester and End-semester examinations; inter-semester breaks etc. well in advance of start of a semester. The academic calendar shall usually provide for at least 80 working days (including examination dates) in each semester, excluding holidays and days when classes are suspended.

1.4 The academic calendar will also reflect the scheduled holidays. Classes lost in holidays need not be compensated. In addition to holidays, the Director, in capacity of Chairman Senate, may announce suspension of classes when a situation so demands. Such suspended classes mayor may not be compensated on a weekend/holiday as per decision of the Director.

1.5 Unlike many traditional universities in India, NIT Rourkela's academic programme is based on a direct contact between the teacher and the student. The teacher enjoys considerable freedom in deciding the contents and method of instruction, evaluation and grading. The printed syllabus is a guideline, rather than a legally enforced constraint. It is mandatory for the class (teacher and students) to conduct all scheduled classes. There is no concept of "finishing a course" because the syllabi are flexible, and permit instruction and practice till the last day of the semester.

Course Structure

1.1 The duration of the course leading to M. Tech. degree will ordinarily be two years. A student may, however, opt for the slow pace programme if he does not feel comfortable with the workload. The maximum duration allowed to complete the M. Tech. programme is 4 years (8 semesters).

1.2 The curricula of the different degree programmes as proposed by the respective departments and recommended by the Post-graduate Programme and Evaluation Committee (PGPEC) shall have the approval of the Senate. The departments will also prepare the syllabus of each subject containing the scope of studies and instructions to be imparted which must have the approval of the Senate.

1.3

(a) All subjects will have Lecture - Tutorial Laboratory / Design components (L- T -P) to indicate the contact hours. Theory courses will have 3-0-0 (3 credits) or 3-1-0 (4 credits) structure. Design or laboratory courses will be offered as distinct (0 - 0 - P) courses without being mixed with lecture components. For the benefit of standardization, other combinations, though permitted, should be avoided. There may be a few special courses of structure 0-0-2

(1 credit). Some courses may have pre- and co-requisites. Co-requisite courses may be taken in the same or different semesters.

(b) Normally, subjects based on engineering or scientific principles or on thought provoking information, where it is possible to conduct a closed book examination, will be taught as theory courses, whereas those based on applications and practice (conceptual, computational or experimental) will be covered under Design or Practical courses. The dividing line between the two, however, is fuzzy and will be decided by Departmental Academic Committees.

(c) All subjects will have a credit count 'C'. Teaching of subjects will be reckoned in terms of credits.

(d) Every course, identified by a single course identifier, shall be taught by a single teacher, who may be assisted by adjunct faculty, teaching assistants, postgraduate and research students, and by other faculty members. The administrative responsibility including decision on contents of instruction and examination as well as submission of grades shall rest solely on the subject teacher. The academic office will recognize only one teacher per course, who will be a regular member of the Institute faculty unless otherwise arranged with approval of Director.

(e) Student feedbacks on courses [Forms AC/118 and AC/119] assist a teacher to improve the contents and delivery. It is the duty of every student to give his thoughtful response to the questions in Form AC/118.

1.4 The prescribed coursework shall be grouped under 2 heads - core courses and professional electives. The core courses, not to exceed 40% of the course load will cover all essential skills associated with a given department and specialization. Professional electives will be taken from a list prescribed by the department, covering courses from the same and allied departments. These courses shall reflect the different specialized topics in a field including the latest developments taking place around the world. Provision of electives helps a student to further specialize on his chosen field.

1.5 The total number of credits in the coursework and seminars in 1st and 2nd semesters together will range between 46 and 50 credits, and that in the entire programme shall be between 98 and 102 credits.

1.6 The summer vacation will constitute a part of the 3rd semester. A student will carry out a mini project during the summer vacation, which should be distinguished from the traditional summer training or SIRE (Short term Industrial or Research Experience) undergone by UG students. The summer project (an internship in industry or an R&D institution, an assigned work in the Institute or a combination of the three) will carry 4 credits which will be counted in the 3rd semester.

The summer project (either in-house or industrial) will be assigned and monitored by the student's thesis supervisor. It may be related to the thesis topic or may be an independent work, to be decided by the thesis supervisor. The topic and place of work will be decided before the middle of the Spring Semester.

There is no summer or winter vacation for M.Tech. Students

1.7 In addition to regular course work, an M. Tech. student must carry out a major project in final year under the guidance of one or two supervisors. The project will be of 2 semester duration and carry 20 credits in each semester. While the Principal Supervisor shall normally be a faculty member of the department, the second supervisor can be from the same or another department, or from another organization. In special circumstances, the Principal Supervisor may be from another department.

1.8 Every programme shall provide a "Seminar and Technical Writing" course [2 credits] during the 3rd and 4th semesters where the students shall learn and practice essential writing and presentation skills, and attend seminars by reputed engineers and scientists organized by the Departments. Each student will also present 1 or 2 seminars and/or poster presentations before

his class. Evaluation will be based on attendance in departmental and Institute seminars, presentation in seminars, poster presentations and technical writing supervised by the course teacher.

1.9 The 4th semester programme shall contain a comprehensive viva voce of 4 credits. It will cover all material learnt in course work over the first two semesters and basic skills learnt in course of the project work. It will be conducted by a board constituted by the HOD in consultation with the DAC (PG&R).

1.10 When circumstances so permit, it will be possible for a student to spend a semester or more in another NIT, IIT or another reputed institute of comparable standing and transfer the credits to NIT Rourkela. The core (compulsory) courses need to have a one-to-one correspondence between the participating institutions. The Senate shall constitute a course equivalence committee to establish the adequacy of the education received in another institution.

1.11 All instructions, practices and examinations will use the SI system of units or any unit system recognized by Government of India.

1.12 Slow Pace programme for local students: The M. Tech. programme is also offered in the slow pace mode to students from Rourkela area who are employed in Government or private institutions and cannot join full time programmes. Under the slow pace programme a student will be registered for half the courses in a semester and will take 4 semesters to complete the course work, and upto 4 years to complete the full programme. There is no other concession and no compromise in quality. The student is not entitled to a hostel room but will be attached to a hostel for administrative purposes. He needs to pay full tution and other fees for all semesters of study even if he takes only partial academic load. In case a student completes 8 semesters with a few F grades or has a course CGPA less than 6.00, he must leave the Institute without obtaining a degree.

Registration

1.1 Every student of the M. Tech. programme is required to be present and do semester registration at the commencement of each semester on the date fixed and notified in the Academic Calendar. The registration process has 3 components:

(a) Physical presence of the student in campus on the first day of semester.
(b) Payment of semester fees including any unpaid dues of past semesters, and
(c) Selection of courses to be studied during the semester

For selection of courses, a "Pre-Registration" process may be organized during the previous semester. Based on pre-registration data, low demand courses may be dropped, student strength in high-demand courses may be limited and sections may be formed.

If courses of a student's choice are not available, he may be given alternative courses with approval of his Faculty Advisor.

1.2 Registration of students in each semester will be organized by the Academic Section. The registration will be done in respective departments supervised by the Faculty Advisors; the choice of subjects being finalized by the student and his Faculty Advisor. Payment of dues etc. will be verified by the Academic Section. An appropriate semester registration form (Form AC/109) will be used for the purpose.
Once registered, a student may amend the registration within a week of the original registration date. The same form (AC/109) shall be used for the purpose with "Amended Registration" written on the top.

1.3 A student who does not register on the day announced for the purpose may be permitted by Dean (AA), in consideration of any compelling reason, late registration within next 5 working

days on payment of an additional fee as prescribed by the Institute. Normally no late registration shall be permitted after the fifth working day from the scheduled date, except in special cases like those directed by MHRD or MHRD approved authorities in 1st semester, a serious medical problem, a family calamity or participation in a national event, to be approved by the Director on recommendation of Dean (AA). However, under no circumstances, late registration after 45 calendar days from the scheduled date of registration is allowed. A student must repeat the semester in the following year. The percentage of attendance of students registering late will be calculated from the date of their joining. However no special allowance may be claimed in the matter of assessment / evaluation or grading.

1.4 Students who have become non-resident with approval of the Institute may be permitted late registration by Dean (AA). They may register anytime during the semester; but registration must be done in person.

1.5 Only those students will be permitted to register who have:

(i) Cleared all Institute and Hall dues of the previous semesters
(ii) Paid all required prescribed fees for the current semester
(iii) Not been debarred from registering for a specified period on disciplinary or any other ground,
(iv) Satisfied the academic requirements of the course,
(v) Not been struck off from the rolls of the Institute

1.6 Students who secure CGPA less than 6.00 but above 5.00 in the First Semester will be permitted to register in the Second semester. Fellowship will be temporarily suspended till publication of second semester results. If the CGPA improves above 6.00, fellowship will be restored with arrears. If the CGPA is still less than 6.00 at the end of second semester, the student shall leave the institute. The unpaid scholarships of second semester will not be paid.

1.7 To be able to register in the 2nd year (3rd semester) and continue his/her study in the Institute at the end of 1st year, a student must

i) complete satisfactorily at least 32 credits of courses prescribed for the two semesters, i.e., secure 'P' or higher grade in at least 32 credits. [The courses with F grade must be cleared as backlog papers in 3rd and 4th semesters to qualify for a degree.], and
ii) obtain a Cumulative Grade Point Average (CGPA) of not lower than 6.00 (considering all courses including those in which the student has secured an F grade).
iii) The method for calculating SGPA and CGPA is illustrated in Appendices I & II.

1.8 While registering in 3rd or 4th semester, a student will register for backlog papers of 1st or 2nd semester respectively. A student need not attend classes in papers registered as "backlog papers". He has to sit for both mid-semester and end-semester examinations and the grade will be awarded based on the scores of the latest examinations. The Teacher's assessment component will be same as that given by the instructor in the original semester, when he attended classes. The registration for backlog papers must be done at the time of semester registration. In all such cases of "backlog paper", the grade awarded will be one step lower than what the student actually obtained, except for the grade 'P' which remains unchanged. A student can appear in a backlog paper only once per subject, in the year following the year when he took the course for the first time.

1.9 Alternatively, a student may opt to repeat a course afresh, in which case he will attend classes, and there will be no reduction of grade awarded. He will, however, be ineligible for awards of medals and prizes which are based on academic performance. If regulations and examination schedule otherwise permit, a student may register for an even semester elective in odd semester and vice versa. A student may change an elective course if he satisfies the pre-requisites and if the timetable permits.

1.10 Ordinarily a student is not permitted to repeat a course in which he has obtained a P or higher grade. But if his CGPA is less than 6.00 he may repeat courses to improve the grade. He is

also permitted to replace one elective course by another. In such cases, he will be ineligible for medals and prizes based on academic performance.

1.11 A student who has been debarred from appearing at an examination either (i) as a measure of disciplinary action or (ii) for adopting malpractice at an examination and consequently awarded a grade 'X', may register for the subject(s) as backlog papers in the following semester, if he satisfies attendance requirements. Otherwise he needs to formally register for the courses and attend classes.

1.12 If a student is debarred from examination or his paper cancelled due to unsatisfactory attendance, he will be given UR grade in that paper. He will need to register for the course afresh and attend classes.

1.13 If a student spends a part of his time in third or fourth semester in course work (except as backlog papers) as a consequence of poor grades or unsatisfactory attendance in first two semesters, his thesis submission date will be forwarded by one semester. His thesis will be evaluated along with those of the next batch students, and he will be awarded the degree in the following year. The extension period will be without fellowship.

Attendance and Leave

1.1

a) Unlike many examining universities, NIT Rourkela's academic programme is based primarily on the teaching-learning process. Attendance in classes, participating in class room discussions and participating in the continuous evaluation process is the most essential component of the academic programme. All teachers and students must appreciate that the number of classes scheduled for a course under the approved academIc calendar and time table must be held during the semester. Form AC/117 gives the format of a monthly attendance sheet.

b) If because of personal leave or official duty, or on student request, a teacher is unable to hold a class on the scheduled hour, he will hold the compensating classes at a mutually convenient hour. A teacher may communicate with his class by announcing in the class, through messages on Institute and hostel notice boards or through e-mail. Attendance in these compensatory classes is mandatory for every student.

c) Under special situations, when a teacher is unable to communicate with the students in advance about his absence from a scheduled class, the students present may mark their attendance in the departmental office. If the class is compensated by the teacher on a later date, this attendance sheet will be replaced by the attendance record provided by the teacher.

d) A teacher, at his discretion, may hold additional classes beyond what is originally scheduled, particularly when several classes are lost due to holidays or suspension of classes. Attendances in these classes are also mandatory for the students.

1.2 Attendance in all classes (Lectures, Tutorials, Laboratories, and Seminars etc.) is compulsory. A student shall be debarred from appearing at an examination or, if he has already written the examination, the grades will be rejected on ground of unsatisfactory attendance, if the attendance is below what is prescribed in clause 7.3, or if in the opinion of the course teacher the student has not participated effectively in the class in terms of home assignments, class tests etc.

In such a case a student shall be given UR grade, and the student will need to register for the course once again and attend classes with seriousness.

1.3

a) Considering that attendance in classes, participating in the teaching-learning process is the basic foundation of our academic programme, a student is expected to attend all classes conducted as per Institute calendar and time table.

However, to provide for exigencies, absence to the extent of 15% of scheduled number of classes in every course will be condoned as a matter of routine.

b) In deserving cases, a further relaxation of 15% (i.e., 30% of scheduled number of classes) may be made by Dean(AA); but the student's grade will be reduced by one step. A 'P' grade will be reduced to 'F', and the student will be permitted register for the course as a backlog paper in the following year.

c) The following table gives the number of classes that a student may miss with or without penalty in grade.

L-T-P	Without Penalty	With reduction of one step in grade
3-0-0	6	12
3-1-0	8	16
0-0-3	2	4

It may be noted that missed classes are of 1 hour duration in theory courses and of 3 hour sessions in lab (0-0-3) courses.

d) If a student has attendance lower than that prescribed under item (c), he will get UR grade. He may register in a summer course if offered or register for the course in a subsequent semester. In the latter case he may not be able to complete the programme in two years.

e) The Institute will fix a cutoff date before every examination to compute the percentage of absence.

f) In case there are truly exceptional circumstances, the Senate or the Director as Chairman Senate, may relax attendance requirements as they think fit.

1.4 It is possible for a student to get leave of absence from classes in deserving cases [Use Form AC/110 to apply for leave]. Dean (AA) may sanction leave on recommendation of Faculty Advisor and Head of the Department on one of the following grounds:

(i) Upto 10 working days of CASUAL LEAVE per year for incidental purposes.

(ii) Upto 15 (including intervening holidays) days of medical leave per year based on prescription of "Unfit for class" by Institute Medical Officer or on hospitalization and post-hospitalization rest approved by attending physician of the hospital, countersigned by Institute Medical Officer. The medical rest recommended by Institute Medical Officer must be on the student's medical record book, and that of external hospitals on the discharge certificate. Advice of rest must be dated prior to the rest period, not later, except under special circumstances**. It may be noted that such advice of rest is not sufficient for missing examinations, for which a specific recommendation must be obtained on Form AC/112.** The first five days of medical leave will count towards payment of fellowship, but not for satisfying attendance requirement. It is because the 15% concession in attendance requirement includes few days of minor sickness.

(iii) Participation in inter-NIT or other national level student competitions inside or outside the Institute. To avail such leave of absence from classes, a student should be selected by SAC to represent the Institute through a process of open competition. A copy of appropriate office order of SAC must be enclosed with the application. (Limited to 5 working days per semester.) [use Form AC/111]

(iv) for academic work or presentation of papers related to final year project, if the project involves visit to Industry or other Institutes or to participate in a Conference. The application must be recommended by the Project Guide and relevant documents are to be enclosed. (Limited to 5 working days in a semester.) [use Form AC/111]

(v) for officially arranged placement programmes on recommendation of Professor, T & P. (Limited to 5 working days in a semester.) [use Form AC/111]

(vi) The Director, as Chairman Senate may approve leave beyond this period upto 40 working days on ground of prolonged illness or unusually serious circumstances. Consideration will be given to students who give prior and continuous information either

directly or through parents, project guide or faculty advisor. Family functions (social or religious), illness of family members, participation in student activities such as organizing functions or raising money, preparing for other examinations or searching of jobs are not adequate grounds for leave of absence from classes (including project work).

It should also be appreciated that a single student is unlikely to require all the categories of leave listed above during all the semesters. The Dean (AA) or Director will sanction leave under any of the above categories only when he is convinced that the leave will not adversely affect the student's academic programme.

1.5 A student will give a list of missed classes (course wise) in his leave application. If approved, the student will be deemed to be present in classes during that many hours for the purpose of computing unauthorized absence from classes.

1.6 In the project period (3rd and 4th semesters), if a student has poor attendance or unsatisfactory record of active work in. the department, as perceived by the supervisor and concurred by the DAC, the date of thesis submission shall be extended by 2 to 6 months without fellowship. The evaluation of the thesis may be done along with the student's batch mates or with students of next batch as decided by DAC.

1.7 A student may be given mess rebate (in units of one day) by the Warden of the hall for the period of approved leave and permission to leave station. For this purpose he must produce the approval by the competent authority and submit a photocopy if the Warden so desires. Medical 'rest' while in Rourkela will not qualify for mess rebate, nor will absence from hostel without proper approval to leave station. Minimum duration of absence should be 5 days to qualify for mess rebate.

1.8 No sanction of leave is necessary if a student wants to leave station over weekend or holidays, except when there is a scheduled compensatory class. No mess rebate is admissible for such absence. The student, however, is required to inform the Warden of his hall of residence before leaving Rourkela.

1.9 Form AC/111 will be used by students seeking permission with or without financial support to travel for academic or extra-curricular work. Such absence from classes shall NOT be counted as leave.

Assessment of Performance

1.1 There will be continuous assessment of a student's performance throughout the semesters and grades will be awarded by the Subject Teacher.

1.2 In general, there is no strict marks-to-grade linkage. The following should be taken as a guideline to ensure uniformity of grading among, all courses.

(a) For arriving at a grade obtained by a student for a particular subject, initially numeric marks obtained by the student out of 100 (hundred) are to be determined and then the same is to be converted to letter grade following the guidelines given in Appendix-II.

(b) For theory subjects, the subcomponents and the respective weights assigned to them are given below.

Subcomponent	**Weight**
Teacher's Assessment (T.A.)	20%
Mid-Semester Examination	30%
End-Semester Examination	50%

(c) For assigning marks in Teacher's Assessment (T.A.), performance in home assignments, class tests, tutorials, quizzes, viva-voce, attendance etc. are to be considered. It is recommended that at least two class tests for 4 credit theory courses and 1 test for 3 credit theory courses are to be conducted for a subject. The weights of different subcomponents of T.A. may be announced to the students by the teacher at the beginning of the Semester.

(d) In case of students given an F, lor X grade, the teacher must submit the marks under T.A. head to the Department Office for use in future.

(e) For assignment of marks in design/ laboratory component (P - component) the relevant subcomponents that are to be considered are: day-to-day work, regularity, tests, assignments, viva-voce etc. Percentage weights of the different subcomponents in deciding the final marks are to be announced at the beginning of the Semester. The evaluation process must be completed before the beginning of end semester examination.

Unlike purely examining universities, design and laboratory courses at NIT Rourkela will put greater emphasis on day to day work than on end semester examinations. To the extent possible, design and laboratory work should be completed and evaluated every class thus ensuring continuous evaluation. Final examination and/or viva voce, if any, may not carry more than 20% marks. No external examiner shall be associated with evaluation of design/laboratory or theory courses.

1.3 Class tests, assignments, tutorials, viva-voce, laboratory assignments, etc., are the constituent components of continuous assessment process, and a student must fulfill all these requirements as prescribed by the teacher of the subject. If due to any compelling reason (such as participation in national/international events with due approval of the institute, personal illness, calamity in the family, etc.) a student fails to meet any of the requirements within the scheduled date and time, the teacher may take such steps (including conduction of compensatory tests/examinations) as are deemed fit to ensure a fair assessment.

Examination

1.1 The departments will conduct the Mid-semester and End-semester Examinations in respect of theory subjects unless otherwise arranged. The Chairman of the Departmental Academic Committee (PG&R) will arrange the examination schedule, invigilation duties, and dispatch of answer scripts to the teachers and collection of grades. In departments with a single M.Tech. Programme, the course teacher may conveniently (not mandatory) be assigned the invigilation duty for the examination. The examinations will normally be "closed book type", where the students are not permitted to bring any material from home or hostel. All necessary charts, tables, codes etc. will be provided by the department. It is the teacher's responsibility to ensure that the required materials are made available to the invigilators. While normal scientific calculators are permitted, other electronic devices such as advanced programmable calculators and calculators containing communication devices are forbidden. Any exception to these provisions must be specially approved by the Senate.

On request from a department, the Institute shall provide sick room facility with medical attention inside the Institute building or in a nearby hospital as deemed convenient by the Institute to assist students who may fall sick during the examinations.

1.2 (a) A student will be permitted to appear in an examination, only if he/she has:

(i) attendance record as per these regulations in theory and laboratory classes and has completed the assignment works given.

(ii) paid all Institute and Hall dues of the semester.

(iii) not been debarred from appearing in the examination as a result of disciplinary proceedings, or on recommendation of the subject teacher.

(iv) has formally registered for the subjects at the beginning of the semester.

(b) A student may be debarred from appearing at the Mid-Semester or End-Semester Examination in the subject on the report of Subject Teacher if his

(i) attendance at lecture/tutorial/ laboratory classes in that subject has not been satisfactory during the period, and/or,

(ii) Performance in the assignment works in that subject during the semester has not been satisfactory.

1.3 The final grades awarded to the students in a subject must be submitted by the teacher, within ten days from the date of holding the Examination to the concerned Head of the Department for onward transmission to the Examination Office, which has to be done by the. Head on the same or next working day. The teacher will submit a separate report on all students obtaining F 0T I grades on Forms AC/121 and AC/122. A teacher, at his discretion, may display the grades (including partial lists) on his door or on any electronic forum. Display of grades by a teacher is for benefit of students, and cannot be cited for legal purposes.

1.4 The Examination Office will place the results and statistical reports of all examinations before the PGPEC, which will examine them and recommend to the Senate for approval. In case the Senate meeting is delayed, the recommended results can be published with approval of the Chairman, Senate. The same may be ratified by the Senate it its next meeting. The Senate has the authority to correct any mistake in the results, even if they are already approved by the Chairman.

1.5 For the benefit of and as a process of learning by the students, the scripts after correction of all class tests, mid-semester examinations assignments etc. will be shown to the students within 3 weeks from the date of Tests / Examinations. The evaluated scripts of the end-semester examinations are to be shown to the students at the beginning of the next semester, but not later than 2 weeks from the starting of classes. There is no limit on how early a teacher can show the evaluated scripts to the students.

1.6 Any change of grade of a student in a subject [Form AC/120], consequent upon detection of any genuine error of omission and/or commission on part of the concerned teacher, must be recommended by the Departmental Academic Committee and forwarded by the Head of the concerned Department to the Examination Office within three weeks from the date of commencement of the next semester. Every Department will send one comprehensive report for each semester in a standard format.

1.7 If a student is dissatisfied with his/her grade, he/she may bring it to the attention of the teacher within two weeks from the first day of commencement of classes in the next semester. The teacher may change the grades if he finds an error in evaluation. The teacher will report the change of grade to the Departmental Academic Committee [Form AC/120] along with all relevant papers (answer scripts, attendance register etc.) before a specified date. The DAC will submit a consolidated report as per standard form to the Examination office for correction of records. If the student still feels aggrieved, he/ she will file a formal complaint with Dean (AA) through his/her faculty advisor and HOD with a copy to the teacher (evaluator). If no complaint is filed within one month from the first day of classes in the next semester, the student is deemed to have accepted the results and no further change of grade is permitted.

1.8 The teachers are expected to retain all answer scripts, assignments and laboratory records for a period of two months from the starting of classes in the next semester. After that the material may be disposed off, except for the students who have filed a complaint. In case of complaint filed before the expiry of two months, the material need to be saved till all disputes are settled and final grade awarded. All relevant material will be handed over by the teacher to the Head of the Department for safe keeping in the department office. The teacher, at his discretion, may retain a photo copy.

1.9 There is no provision for supplementary or alternative mid semester exams in an M.Tech. Course. A student who secures an F grade in First or Second semester or misses an examination due to a compelling reason, may appear at the examinations during 3rd or 4th semester as backlog papers, the later being subject to satisfactory attendance record. In such cases the grade will be reduced by one step, except in case of P grades which remain unchanged. A student can get full credit if he misses examination for a compelling reason and has over 95% attendance. If a student does not satisfy attendance requirements, he will have to formally register for the courses during 3rd or 4th semesters, in which case his date of thesis submission gets deferred.

Withdrawal

1.1 In case of a student already employed, or if he secures new placement (including long term internship), he may be allowed to become nonresident on the recommendation of Faculty adviser and Head of the Department and with approval of Dean (AA) after he has completed successfully two semesters of course work. [Students with any F, I, X or UR grade at the end of second semester will not be granted withdrawal.] The student so permitted has to pay the prescribed fees in all subsequent semesters till submission of thesis. In such cases, however, the student has to submit the dissertation not later than four years from the date of admission.

1.2 The following arrangement will be made for carrying out the project after a student takes withdrawal from the Institute in accordance with clause 10.1:

(i) If the withdrawal is taken before the end of the autumn semester, it will be necessary for the student to start afresh on his project with a joint supervisor from his employing organization. The student has to identify a suitable supervisor from the organization where he joins and submit the bio-data of the supervisor, his willingness to supervise the student and the consent of the organization to the Departmental Supervisor, who shall subsequently forward it to the Dean (Academic Affairs) through HOD for approval. The student can submit thesis from outside with a delay of at least one year.

(ii) If the withdrawal is taken after completion of the autumn semester, the student can work under the guidance of his present supervisor (if the supervisor certifies it to be feasible) and submit his thesis at least one year after his normal date of submission.

(iii) As a special case of clause 10.3 (ii), if the withdrawal is sought within one month prior to the scheduled date of thesis submission, the student is required to ask the employer for an extension of date of joining. If not agreed to by the employer, he may be granted withdrawal by Dean (AA). Copies of all relevant correspondence need to be submitted by the student to establish that an honest attempt was made by the student and his supervisor to obtain an extension of joining date. In such a scenario, the student may submit a partial thesis for evaluation. He / She can also appear at viva voce examination along with his batch mates. He / She will submit the complete thesis after putting in additional work before the end of following autumn semester which will be evaluated by a departmental board for award of the final grades. He / She will be awarded degree along with the next batch of students.

1.3 Students will not be entitled to any fellowship after taking withdrawal from the course.

Project Work and Submission of Thesis

1.1 The project is an important component of the Institute's M.Tech. programme. It gives an opportunity to the student to express his creative talents and prepare for his future career.

1.2 Each topic will be taken by one student only. In case of specially challenging problems, larger teams may work on a single problem, with the prior approval of Dean (AA).

1.3 The Departmental Academic Committee will invite research topics for M.Tech. projects from its own faculty (including adjunct faculty) and from other departments across the Institute towards the middle of the first semester. One member of the Committee may be designated to coordinate this activity. Faculty members may propose project topics, singly or in collaboration with a colleague from the same or another department. Co-Supervisors from industry or other institutions may also be accepted. The topics should be advanced in academic content and, preferably, relevant to industry/field application. It is expected that research topics offered by an academic group fall into a pattern, and reflect the long term research plans of the faculty members.

1.4 The Departmental Academic Committee will assign research topics to students at the end of the first semester (preferably by September 30), after taking into consideration the requirements of the projects and choice of the students.

Initial assignments of projects will generally be broad titles, which will crystallize as the work progresses. It is not mandatory for the student or his supervisor to inform the DAC about such incremental changes. In case of a major change of field during the course of a work, the DAC should be informed to decide if the student shall need additional time to complete the work.

1.5 M.Tech. projects may be analytical, computational, experimental or developmental or combination thereof. The department will make the necessary resources available to the students, including access to laboratory and computing facilities outside normal working hours. It will be the moral and legal responsibility of the supervisor (s) to arrange the facilities. Students are encouraged to discuss such matters with their supervisors, and if not satisfied, with HODs and higher authorities.

1.6 The Institute encourages research projects in collaboration with industry, R&D organizations and other reputed educational institutions. Such projects must be proposed and actively pursued by the faculty supervisor, instead of being a private arrangement between the student and the external Institution. The supervisor may propose to DAC a co-supervisor from the collaborating institution. The student may accept financial support from the external institution, to offset the additional cost of travel, and living expenses. But he cannot accept a second fellowship/scholarship while enjoying a fellowship from the Institute.

The Institute specifically discourages internships in industry where a student works in an organization without active participation by his supervisor in pursuing the research topic. Indicators of such arrangement are initiation of a problem after allotment of research topics, interview of the student by the company, long stay of student in the premises of the employing organization with intermittent visit to the Institute, absence of meetings between the supervisors from the industry and the Institute, withholding of information in the thesis by the company, absence of share of IPR to the faculty supervisor etc. Reputation of the industry, expertise of its engineers and standard of the research topic do not justify non-participation of the student in the Institute's academic programme.

1.7 The Head of the Department is the competent authority to approve travel of students for all academic purposes including those for working on research projects irrespective of the duration. Travel support from the Institute, however, needs to be approved by Dean (AA).

1.8 Each student will be given an official "Project Record Book" by the Institute. A guideline for Project Book is given in Appendix-III. All concepts, drawings, formulas, derivations, experimental observations, graphs, charts, photographs, computer flow charts and pseudo codes must be recorded by the student on this note book, which must be produced before all evaluation boards. There shall no blank pages in between the writings.

1.9 The student is required to submit formal project reports at the end of 3rd and 4th semesters that submitted at the end of the 4th semester being in the form of a well bound thesis. The Departmental Academic Committee will constitute one or more evaluation boards, for continuous monitoring of the projects. The Boards will examine the day to day records and conduct viva-voce and/or oral presentations by the students at least twice in each semester.

1.10 For the purpose of assignment of a grade in the 3rd semester, the following will be weightage of the different components:

Mid Semesters assessment by Supervisor (s) (based on day to day work and record book)	=	20%
Mid Semester assessment by Evaluation Board (based on record book only)	=	20%
End Semester assessment by Supervisor(s) (based on day to day work and record book)	=	20%
End Semester Assessment by Evaluation Board	=	20%

(based on oral presentation, viva-voce and record book)
Interim Project Report = 20%
(assessed by Evaluation Board)

1.11 For the assignment of a grade in the 4th semester, the following will be weightage of the different components.
Supervisor's assessment
(twice in a semester 20% + 20%) = 40%
Assessment by Evaluation Board along with external examiner through oral presentation and viva -
Voce = 40%
Project Report = 20%
(external examiner)
The external examiners will be selected by Dean (AA) out of a panel of five experts suggested by the Departmental Academic Committee. Depending on the number of students and the variety of topics either one or two external experts may be invited. The invitation will be issued by the AR (Acad), further correspondence regarding date of viva voce and travel plans being made by the HOD or his nominee.

1.12 On completion of the examination process a student shall submit two bound copies of the thesis (three if there are two supervisors) to the Head of the Department - one for the Departmental Library and one copy to each of his supervisors. Loosely bound copies will not be accepted. The student is also required to submit two electronic copies of the thesis in prescribed format (PDF). The paper and electronic copies of the thesis will be archived in Institute and Departmental libraries and will be distributed by the Institute through Internet and other means.

1.13 On completion of evaluation, the Departmental Academic Committee or its subcommittee constituted for the purpose shall decide the grade awarded. If the performance of a student is unsatisfactory, the Committee may recommend one of the following:

(i) Rewriting of report and submission for evaluation.
(ii) Extension of time for completion of the work (the time duration is to be specified), [No fellowship to be given during extension period.)
(iii) Complete repetition of the project in the following year.

The resubmitted thesis will be evaluated by the Committee and the grade will be sent to the examination office. The committee may, at his discretion, seek advice of the external examiner.

1.14 Students who have been absent for a substantial duration during the project period, or have otherwise invested less than required time will be granted extension of time on recommendation of the supervisor or of the Evaluation Board. Such extension will be without fellowship.

The extension of duration shall not be less than the number of days lost by unauthorized absence during the project period.

If the extension of thesis submission is for duration less than 2 months, the oral examination can be carried out along with the same batch students. Otherwise, a student can complete his work and submit his thesis; but his thesis will be evaluated along with the student of next batch.

1.15 Rights to all intellectual property generated in the project shall be distributed equally among the students, technicians and the supervisors, except where the concerned workers mutually settle on a distribution formula. If a project is supported by a sponsor, the sponsoring organization will be given IPR as per the contract, and the balance divided among the faculty, students and technicians.

1.16 Like course credits, it will be possible for a student to carry out his project in another NIT, IIT or institution of comparable standing in India or abroad under the joint supervision of faculty members of both institutions, and transfer the credits to NIT Rourkela. Such arrangements will need the approval of the Senate [or Chairman Senate on its behalf] on case to case basis.

Graduation Requirement

1.1 In order to qualify for the M. Tech. degree of the Institute, a student must:
   (a) complete all credit requirements for the degree as laid down in the prescribed curriculum of the discipline, with a minimum grade' P , in each subject.
   (b) obtain a CGPA of 6.00 or higher at the end of the semester in which he completes all the requirements of the degree, separately in both course work (1st and 2nd semesters) and thesis (3rd and 4th semesters) components.
   (c) have cleared all dues of the Institute, Halls of residence, Library, Department and Student Activity Centre.

1.2 Normally a student should complete all the requirements consecutively in four semesters for the M. Tech. degree. [Six semesters in the Slow Pace programme.] Students taking withdrawal in the middle of a programme will be governed by rules given in Section 10.

1.3 All graduating students are required to submit their suggestion for improvement of courses to the Director in Form AC/123. The suggestions will be summarized on Form AC/124 and presented before the Senate.

1.4 Students who do not satisfy all graduation requirements within 4 years from the date of admission will leave the institute without being awarded a degree.

B. Curricula of M.Sc,Integrated M.Sc, MA and MBA Programmes

Sl. No	Branch. Code	Branch Name	Curricula Page No.	Syllabi Page No.
1	CY	Chemistry		
2	LS	Life Science		
3	MA	Mathematics		
4	PH	Physics		
5	HS	MA in Development Studies (HUMANITIES & SOCIAL SCIENCES)		
6	SM	School of Management		

DEPARTMENT OF CHEMISTRY

Curriculum of M.Sc. (CHEMISTRY)

FIRST SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CY 511	Stereochemistry and Reaction Mechanism	3-1-0	4
2	CY 521	Principles of Inorganic Chemistry	3-1-0	4
3	CY 531	Thermodynamics & Chemical Equlibria	3-1-0	4
4		Professional Elective – I	3-0-0	3
5		Open Elective – I	3-0-0	3
6	CY 571	Organic Chemistry Laboratory	0-0-9	6
7	CS 171	Computing Laboratory – I	0-0-3	2
TOTAL				**26**

SECOND SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CY 512	Structure and Functions of Biomolecules	3-1-0	4
2	CY 522	Chemistry of Transition and Non-transition Elements	3-1-0	4
3	CY 532	Chemical Kinetics and Photochemistry	3-1-0	4
4		Professional Elective – II	3-0-0	3
5		Open Elective – II	3-0-0	3
6	CY 572	Inorganic Chemistry Laboratory	0-0-9	6
7	CS 172	Computing Laboratory – II	0-0-3	2
TOTAL				**26**

THIRD SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CY 533	Quantum Chemistry	3-1-0	4
2		Professional Elective – III	3-0-0	3
3		Professional Elective – IV	3-0-0	3
4		Open Elective – III	3-0-0	3
5	CY 573	Physical Chemistry Laboratory	0-0-9	6
6	CY 591	Research Project – I	0-0-6	4
7	CY 593	Seminar & Technical Writing – I	0-0-3	2
8	CY 595	Short Term Industrial / Research Experience(SIRE)	0-0-0	2
TOTAL				**27**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CY 514	Environmental Chemistry	3-1-0	4
2		Professional Elective – V	3-0-0	3
3		Professional Elective – VI	3-0-0	3
4		Open Elective – IV	3-0-0	3
5	CY 574	Environmental Chemistry Laboratory	0-0-9	6
6	CY 592	Research Project – II	0-0-9	6
7	CY 594	Seminar & Technical Writing – II	0-0-3	2
8	CY 596	Comprehensive Viva – Voce	0-0-0	2
TOTAL				**29**

Curriculum of Integrated M.Sc. (CHEMISTRY)

FIRST SEMESTER(STRUCTURE COMMON TO ALL BRANCHES)

Sl.No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Differential Equations		3-1-0	4
2	PH 101	Physics – I		3-1-0	4
3	CY 101	Chemistry		3-1-0	4
4	EE 100	Basic Electrical Technology	OR	3-1-0	4
	EC 100	Basic Electronics Engineering			
5	CE 100	Engineering Mechanics	OR	3-1-0	4
	CE 130	Environmental and Safety Engineering			
6	PH 170	Physics Laboratory	OR	0-0-3	2
	CY 170	Chemistry Laboratory			
7	CS 171	Computing Laboratory – I		0-0-3	2
8	CE 171	Engineering Drawing		0-0-3	2
9	WS 171	Workshop Practice – I		0-0-3	2
10		Extra Academic Activity – I		0-0-3	2
TOTAL					**30**

SECOND SEMESTER(STRUCTURE COMMON TO ALL BRANCHES)

Sl.No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Matrix theory, Vector Calculus and Fourier Analysis		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithms		3-1-0	4
4	EC 100	Basic Electronics Engineering	OR	3-1-0	4
	EE 100	Basic Electrical Technology			
5	CE 130	Environmental and Safety Engineering	OR	3-1-0	4
	CE 100	Engineering Mechanics			
6	CY 170	Chemistry Laboratory	OR	0-0-3	2
	PH 170	Physics Laboratory			
7	CS 172	Computing Laboratory – II		0-0-3	2
8	ME 170	Machine Drawing and Solid Modeling		0-0-3	2
9	ME 172	Workshop Practice – II		0-0-3	2
10		Extra Academic Activity – I		0-0-3	2
TOTAL					**30**

THIRD SEMESTER

Sl.No	Sub.Code	Subjects	L-T- P	Credits
1.	CY 221	Chemistry of Industrial Materials	3-1-0	4
2.	CY 231	Basic Physical Chemistry – I	3-1-0	4
3.	PH 201	Thermodynamics	3-1-0	4
4.	MA 207	Introduction to Numerical Analysis	3-1-0	4
5.		HS & Open Elective – I	3-0-0	3
6.	MA 270	Numerical Methods Laboratory	0-0-3	2
7.	CY 271	UG Organic Chemistry Laboratory	0-0-3	2
8.	PH 271	Thermal Laboratory	0-0-3	2
TOTAL				**25**

FOURTH SEMESTER

Sl.No	Sub.Code	Subjects	L-T-P	Credits
1.	CY 214	Basic Organic Chemistry – I	3-1-0	4
2.	CY 234	Basic Physical Chemistry – II	3-1-0	4
3.	PH 202	Electricity and Magnetism	3-1-0	4
4.	MA 206	Introduction to Complex Analysis and Partial Differential Equations	3-1-0	4
5.		HS & Open Elective – II	3-0-0	3
6.	CY 273	UG Physical Chemistry Laboratory	0-0-3	2
7.	PH 272	Electricity and Magnetism Laboratory	0-0-3	2
8.	HS 270	Language Laboratory	0-0-3	2
TOTAL				**25**

FIFTH SEMESTER

Sl.No	Sub.Code	Subjects	L-T-P	Credits
1.	CY 312	Basic Organic Chemistry – II	3-1-0	4
2.	CY 322	Basic Inorganic Chemistry – I	3-1-0	4
3.	MA 301	Group Theory	3-1-0	4
4.	PH 301	Waves and applications	3-1-0	4
5.		HS & Open Elective – III	3-0-0	3
6.	CY 375	Instrumentation Laboratory	0-0-3	2
7.	PH 371	Waves and Optics Laboratory	0-0-3	2
8.	MA 371	Lab works on Abstract Algebra	0-0-3	2
TOTAL				**25**

SIXTH SEMESTER

Sl.No	Sub.Code	Subjects	L-T-P	Credits
1.	CY 313	Natural Products	3-1-0	4
2.	CY 323	Basic Inorganic Chemistry – II	3-1-0	4
3.	PH 302	Properties of Matter	3-1-0	4
4.	MA 332	Probability	3-1-0	4
5.		HS & Open Elective – IV	3-0-0	3
6.	CY 374	UG Inorganic Chemistry Laboratory	0-0-3	2
7.	PH 374	Properties of Matter Laboratory	0-0-3	2
8.	MA 372	Statistics Laboratory	0-0-3	2
TOTAL				**25**

SEVENTH SEMESTER

Sl.No	Sub.Code	Subjects	L-T-P	Credits
1.	CY 511	Stereochemistry and Reaction Mechanism	3-1-0	4
2.	CY 521	Principles of Inorganic Chemistry	3-1-0	4
3.	CY 531	Thermodynamics & Chemical Equlibria	3-1-0	4
4.		Professional Elective – I	3-0-0	3
5.		HS & Open Elective – V	3-0-0	3
6.	CY 571	Organic Chemistry Laboratory	0-0-9	6
7.	CY 581	Research Project – I	0-0-6	4
TOTAL				**25**

EIGHTH SEMESTER

Sl.No	Sub.Code	Subjects	L-T-P	Credits
1.	CY 512	Structure and Functions of Biomolecules	3-1-0	4
2.	CY 522	Chemistry of Transition and Non-transition Elements	3-1-0	4
3.	CY 532	Chemical Kinetics and Photochemistry	3-1-0	4
4.		Professional Elective – II	3-0-0	3
5.		HS & Open Elective – VI	3-0-0	3
6.	CY 572	Inorganic Chemistry Laboratory	0-0-9	6
7.	CY 582	Research Project – II	0-0-6	4
TOTAL				**28**

NINTH SEMESTER

Sl.No	Sub.Code	Subjects	L-T-P	Credits
1.	CY 533	Quantum Chemistry	3-1-0	4
2.		Professional Elective – III	3-0-0	3
3.		Professional Elective – IV	3-0-0	3
4.		HS & Open Elective – VII	3-0-0	3
5.	CY 573	Physical Chemistry Laboratory	0-0-9	6
6.	CY 583	Research Project – III	0-0-9	6
7.	CY 593	Seminar & Technical Writing – I	0-0-3	2
8.	CY 595	Short Term Industrial / Research Experience(SIRE)	0-0-0	2
TOTAL				**27**

TENTH SEMESTER

Sl.No	Sub.Code	Subjects	L-T-P	Credits
1.	CY 514	Environmental Chemistry	3-1-0	4
2.		Professional Elective – V	3-0-0	3
3.		Professional Elective – VI	3-0-0	3
4.		HS & Open Elective – VIII	3-0-0	3
5.	CY 574	Environmental Chemistry Laboratory	0-0-9	6
6.	CY 584	Research Project – IV	0-0-9	6
7.	CY 594	Seminar & Technical Writing – II	0-0-3	2
8.	CY 596	Comprehensive Viva-Voce	0-0-0	2
TOTAL				**27**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subjects	L-T- P	Credits	Offered To
1	CY 515	Spectroscopic Methods of Analysis	3-0-0	3	#
2	CY 516	Industrial Organic Chemistry	3-0-0	3	#
3	CY 517	Chemistry of Natural Products	3-0-0	3	#
4	CY 518	Polymer Chemistry	3-0-0	3	#
5	CY 519	Pericyclic Reactions and Photochemistry	3-0-0	3	#
6	CY 523	Industrial Inorganic Chemistry	3-0-0	3	#
7	CY 524	Group Theory and Molecular Orbitals	3-0-0	3	#
8	CY 525	Advanced Co-ordination Chemistry	3-0-0	3	#
9	CY 526	Bio-inorganic Chemistry	3-0-0	3	#
10	CY 527	Supramolecular Chemistry	3-0-0	3	#
11	CY 534	Principles of Heterogeneous Catalysis	3-0-0	3	#
12	CY 535	Electrochemistry	3-0-0	3	#
13	CY 536	Colloids and Surface Chemistry	3-0-0	3	#
14	CY 537	Advanced Solid State Chemistry	3-0-0	3	#
15	CY 538	Molecular Spectroscopy	3-0-0	3	#
16	CY 539	Biophysical Chemistry	3-0-0	3	#
17	CY 541	Chemistry of Heterocyclic Compounds	3-0-0	3	#
18	CY 542	Methods on Organic Synthesis	3-0-0	3	#
19	CY 543	Molecular Rearrangement	3-0-0	3	#
20	CY 544	Instrumental Methods of Analysis	3-0-0	3	#
21	CY 558	Organometallic Chemistry	3-0-0	3	#

Note: # - for both M.SC and Integrated M.Sc. courses

LIST OF OPEN ELECTIVES

Sl. No	Sub.Code	Subject	L-T-P	Credits	Non Eligible Branches
1	CY 211	Name Reactions & Rearrangements	3-0-0	3	-
2	CY 232	Chemical Kinetics	3-0-0	3	CH
3	CY 311	Concerted Reactions	3-0-0	3	-
4	CY 413	Spectroscopic Methods of Analysis.	3-0-0	3	-
5	CY 431	Chemistry of Nanomaterials	3-0-0	3	-
6	CY 432	Introduction to Nanobiotechnology	3-0-0	3	-

SUMMARY OF COURSES

Sub Discipline: Core Courses

CY 101	Chemistry	3-1-0	4

Sub Discipline: Organic Chemistry

CY 211	Name Reactions & Rearrangements	3-0-0	3
CY 214	Basic Organic Chemistry – I	3-1-0	4
CY 311	Concerted Reactions	3-0-0	3
CY 312	Basic Organics Chemistry – II	3-1-0	4
CY 313	Natural Products	3-1-0	4
CY 413	Spectroscopic Methods of Analysis	3-0-0	3
CY 511	Stereochemistry and Reaction Mechanism	3-1-0	4
CY 512	Structure and Functions of Biomolecules	3-1-0	4
CY 514	Environmental Chemistry	3-1-0	4

CY 515	Spectroscopic Methods of Analysis	3-0-0	3
CY 516	Industrial Organic Chemistry	3-0-0	3
CY 517	Chemistry of Natural Products	3-0-0	3
CY 518	Polymer Chemistry	3-0-0	3
CY 519	Pericyclic Reactions and Photochemistry	3-0-0	3
CY 541	Chemistry of Heterocyclic Compounds	3-0-0	3
CY 542	Methods on Organic Synthesis	3-0-0	3
CY 543	Molecular Rearrangement	3-0-0	3
CY 544	Instrumental Methods of Analysis	3-0-0	3

Sub Discipline: Inorganic Chemistry

CY 221	Chemistry of Industrial Materials	3-1-0	4
CY 322	Basic Inorganic Chemistry – I	3-1-0	4
CY 323	Basic Inorganic Chemistry – II	3-1-0	4
CY 521	Principles of Inorganic Chemistry	3-1-0	4
CY 522	Chemistry of Transition and Non transition Elements	3-1-0	4
CY 523	Industrial Inorganic Chemistry	3-0-0	3
CY 524	Group Theory and Molecular Orbitals	3-0-0	3
CY 525	Advanced Co-ordination Chemistry	3-0-0	3
CY 526	Bio-Inorganic Chemistry	3-0-0	3
CY 527	Supramolecular Chemistry	3-0-0	3
CY 544	Industrial Methods of Analysis	3-0-0	3
CY 558	Organometallic Chemistry	3-0-0	3

Sub Discipline: Physical Chemistry

CY 231	Basic Physical Chemistry – I	3-1-0	4
CY 232	Chemical Kinetics	3-0-0	3
CY 234	Basic Physical Chemistry – II	3-1-0	4
CY 431	Chemistry of Nanomaterials	3-0-0	3
CY 432	Introduction to Nanobiotechnology	3-0-0	3
CY 531	Thermodynamics & Chemical Equilibria	3-1-0	4
CY 532	Chemical Kinetics & Photochemistry	3-1-0	4
CY 533	Quantum Chemistry	3-1-0	4
CY 534	Principles of Heterogeneous Catalysis	3-0-0	3
CY 535	Electrochemistry	3-0-0	3
CY 536	Colloids and Surface Chemistry	3-0-0	3
CY 537	Advanced Solid State Chemistry	3-0-0	3
CY 538	Molecular Spectroscopy	3-0-0	3
CY 539	Biophysical Chemistry	3-0-0	3

Sub Discipline: Laboratory Courses

CY 170	Chemistry Laboratory	0-0-3	2
CY 271	UG Organic Chemistry Laboratory	0-0-3	2
CY 273	UG Physical Chemistry Laboratory	0-0-3	2
CY 374	Inorganic Chemistry Laboratory	0-0-3	2
CY 375	Instrumentation Laboratory	0-0-3	2
CY 571	Organic Chemistry Laboratory	0-0-9	6
CY 572	Inorganic Chemistry Laboratory	0-0-9	6
CY 573	Physical Chemistry Laboratory	0-0-9	6
CY 574	Environmental Chemistry Laboratory	0-0-9	6

Sub Discipline: Project, Seminar and Special Courses

CY 581	Research Project – I	0-0-6	4

CY 582	Research Project – II	0-0-6	4
CY 583	Research Project – III	0-0-9	6
CY 584	Research Project – IV	0-0-9	6
CY 591	Research Project – I	0-0-6	4
CY 592	Research Project – II	0-0-6	4
CY 593	Seminar & Technical Writing – I	0-0-3	2
CY 594	Seminar & Technical Writing – II	0-0-3	2
CY 595	Short Term Industrial / Research Experience(SIRE)	0-0-0	2
CY 596	Comprehensive Viva-Voce	0-0-0	2

DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES

Vision: To be recognized as a seat of higher learning in the fields of Earth and Atmospheric Science and provider of superior human resource to major national agencies engaged in exploration & exploitation of mineral and energy resources and prediction of weather, climate and natural hazards for disaster mitigation.

Mission:

I. To carry out cutting-edge research in the fields of Earth and Atmospheric Science with the emphasis on application to geological prospective, atmospheric modeling and measurements.
II. To provide education in the field of Earth and Atmospheric Science with an eye on strong fundamentals, research aptitude, devotion to profession and high ethical standards.

Programme Educational Objectives (PEOs)

I. To impart advanced knowledge of science and technology in the fields related to Earth and Atmosphere.
II. To provide a strong background on theoretical, practical and fundamental research oriented understanding.
III. To train the students with the available computational technology for addressing relevant issues.
IV. To focus on the interdisciplinary, qualitative and quantitative way of teaching and research programme.
V. To create well trained scientists to address various challenges faced by industry and society.
VI. Develop analytical skill to communicate effectively in verbal and documented forms.

Programme Outcomes (POs):

I. To create well trained manpower for exploration and exploitation of mineral and energy resources in view of sustainable growth and development of the society.
II. Developing the understanding of internal and surfacial dynamics of the Earth and associated Atmospheric processes.
III. Create efficient researchers to understand and predict weather and climate.
IV. To train people in order to take challenging responsibility for addressing issues relating to environment and natural hazards.

Curriculum of M.Sc. (APPLIED GEOLOGY)

FIRST SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	ER 511	Physical Geology	3-0-0	3
2	ER 512	Crystallography & Mineralogy	3-0-0	3
3	ER 513	Structural Geology	3-0-0	3
4	ER 514	Geochemistry	3-0-0	3
5		Open Elective – I	3-0-0	3
6	ER 571	Crystallography & Mineralogy Laboratory	0-0-3	2
7	ER 572	Structural Geology Laboratory	0-0-3	2
8	ER 573	Geochemistry Laboratory	0-0-3	2
9	CS 171	Computing Laboratory – I	0-0-3	2
TOTAL				**23**

SECOND SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	ER 515	Igneous & Metamorphic Petrology	3-1-0	4
2	ER 516	Sedimentary and Quaternary Geology	3-1-0	4
3	ER 519	Fuel and Economic Geology	3-1-0	4
4	ER 518	Palaeontology	3-0-0	3
5		Open Elective – II	3-0-0	3
6	ER 574	Igneous and Metamorphic Petrology Laboratory	0-0-3	2
7	ER 575	Sedimentary Geology Laboratory	0-0-3	2
8	ER 576	Palaeontology Laboratory	0-0-3	2
9	CS 172	Computing Laboratory – II	0-0-3	2
TOTAL				**25**

THIRD SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	ER 517	Stratigraphy	3-0-0	3
2	ER 520	Hydrogeology	3-0-0	3
3		Professional Elective – I	3-0-0	3
4		Open Elective – III	3-0-0	3
5	ER 577	Core Microscopy Laboratory	0-0-3	2
6	ER 578	Hydrogeology Laboratory	0-0-3	2
7	ER 579	Paleoceanogaphy Laboratory	0-0-3	2
8	ER 591	Research Project – I	0-0-0	4
9	ER 593	Seminar and Technical Writing – I	0-0-0	2
10	ER 595	Short term Industrial/ Research Experience (SIRE)	0-0-0	2
TOTAL				**27**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Elective – II	3-0-0	3
2		Professional Elective – III	3-0-0	3
3		Professional Elective – IV	3-0-0	3
4		Open Elective – IV	3-0-0	3
5	ER 580	Remote Sensing & GIS Laboratory	0-0-3	2

6	ER 582	Coal Geology Laboratory	0-0-3	2
7	ER 585	Modeling and Simulation Laboratory	0-0-3	2
8	ER 592	Research Project – II	0-0-0	4
9	ER 594	Seminar and Technical Writing – II	0-0-0	2
10	ER 596	Comprehensive Viva – Voce	0-0-3	2
TOTAL				**26**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	ER 521	Engineering Geology	3-0-0	3
2	ER 522	Remote Sensing & GIS	3-0-0	3
3	ER 523	Geology of Fuels	3-0-0	3
4	ER 524	Environmental Geology	3-0-0	3
5	ER 525	Isotope Geology	3-0-0	3
6	ER 526	Geophysical Methods	3-0-0	3
7	ER 527	Geostatistics	3-0-0	3
8	ER 528	Introduction to Atmosphere and Ocean Sceince	3-0-0	3
9	ER 529	Tectonic Geodesy: Crustal Deformation & Active Tectonics	3-0-0	3
10	ER 530	Rheology of the Earth	3-0-0	3
11	ER 531	Earthquake and Volcano Deformation	3-0-0	3
12	ER 532	Weather and Climate Systems	3-0-0	3

LIST OF OPEN ELECTIVES

Sl. No	Sub.Code	Subject	L-T-P	Credits	Non Eligible Branches
1	ER 201	Physics of Atmosphere	3-0-0	3	-
2	ER 202	Evolution of Early Earth	3-0-0	3	-
3	ER 203	Coal and Petroleum Geology	3-0-0	3	-
4	ER 204	Global Plate Tectonics	3-0-0	3	-
5	ER 205	Introduction to Weather and Climate	3-0-0	3	-

SUMMARY

Sub Discipline: Earth Science

ER 511	Physical Geology	3-0-0	3
ER 512	Crystallography & Mineralogy	3-0-0	3
ER 513	Structural Geology	3-0-0	3
ER 514	Geochemistry	3-0-0	3
ER 515	Igneous & Metamorphic Petrology	3-1-0	4
ER 516	Sedimentary and Quaternary Geology	3-1-0	4
ER 517	Stratigraphy	3-0-0	3
ER 518	Palaeontology	3-0-0	3
ER 519	Fuel and Economic Geology	3-1-0	4
ER 520	Hydrogeology	3-0-0	3
ER 521	Engineering Geology	3-0-0	3
ER 523	Geology of Fuels	3-0-0	3
ER 524	Environmental Geology	3-0-0	3
ER 525	Isotope Geology	3-0-0	3
ER 526	Geophysical Methods	3-0-0	3

ER 527	Geostatistics	3-0-0	3
ER 529	Tectonic Geodesy: Crustal Deformation & Active Tectonics	3-0-0	3
ER 530	Rheology of the Earth	3-0-0	3
ER 531	Earthquake and Volcano Deformation	3-0-0	3
ER 207	Mining Geology	3-0-0	3
ER 202	Evolution of Early Earth	3-0-0	3
ER 203	Coal and Petroleum Geology	3-0-0	3
ER 204	Global Plate Tectonics	3-0-0	3
ER 607	Application of Tectonic Geodesy	3-0-0	3
ER 608	Rock Water Interaction	3-0-0	3
ER 609	Geochronology	3-0-0	3
ER 610	Applied Isotope Geology	3-0-0	3
ER 611	Instrumentation for Earth Scientists	3-0-0	3
ER 612	Petroleum Geology	3-0-0	3
ER 613	Coal Geology	3-0-0	3
ER 614	Geostatistics	3-0-0	3
ER 615	Applied Hydrogeology	3-0-0	3

Sub Discipline: Atmospheric Science

ER 528	Introduction to Atmosphere and Ocean Science	3-0-0	3
ER 532	Weather and Climate Systems	3-0-0	3
ER 201	Physics of Atmosphere	3-0-0	3
ER 205	Introduction to Weather and Climate	3-0-0	3
ER 601	Theoretical Meteorology	3-0-0	3
ER 602	Applied Atmospheric Dynamics	3-0-0	3
ER 603	Introduction to Climate Science	3-0-0	3
ER 604	Boundary Layer Meteorology	3-0-0	3
ER 605	Introduction to Microscale and Mesoscale Meteorology	3-0-0	3
ER 606	Mesoscale Meteorology and Modeling	3-0-0	3

Sub Discipline: Remote Sensing & GIS

ER 522	Remote Sensing & GIS	3-0-0	3
ER 616	Satellite Remote Sensing for Geo-resource Evaluation	3-0-0	3

Sub Discipline: Laboratory courses

ER 571	Crystallography & Mineralogy Laboratory	0-0-3	2
ER 572	Structural Geology Laboratory	0-0-3	2
ER 573	Geochemistry Laboratory	0-0-3	2
ER 574	Igneous and Metamorphic Petrology Laboratory	0-0-3	2
ER 575	Sedimentary Geology Laboratory	0-0-3	2
ER 576	Palaeontology Laboratory	0-0-3	2
ER 577	Ore Microscopy Laboratory	0-0-3	2
ER 578	Hydrogeology Laboratory	0-0-3	2
ER 579	Paleoceanography Laboratory	0-0-3	2
ER 580	Remote Sensing & GIS Laboratory	0-0-3	2
ER 582	Coal Geology Laboratory	0-0-3	2
ER 585	Modeling and Simulation Laboratory	0-0-3	2
ER 273	Mining Geology Laboratory	0-0-3	2
CS 171	Computing Laboratory – I	0-0-3	2

CS 172	Computing Laboratory – II	0-0-3	2

Sub Discipline: Laboratory courses

ER 591	Research Project – I	0-0-0	4
ER 592	Research Project – II	0-0-0	4
ER 593	Seminar & Technical Writing – I	0-0-0	2
ER 594	Seminar & Technical Writing – II	0-0-0	2
ER 595	Short term Industrial/ Research Experience (SIRE)	0-0-0	2
ER 596	Comprehensive Viva-Voce	0-0-0	2
ER 798	Seminar and Technical Writing	0-0-0	2
ER 799	Research Project	0-0-0	-

DEPARTMENT OF LIFE SCIENCE

Curriculum of M.Sc (LIFE SCIENCE)

FIRST SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	LS 401	Microbiology	3-1-0	4
2	LS 402	Biochemistry	3-1-0	4
3	LS 440	Physical Sciences and Instrumentation	3-1-0	4
4		Professional Elective – I	3-1-0	4
5		Open Elective – I	3-0-0	3
6	LS 471	Microbiology Laboratory	0-0-3	2
7	LS 472	Biochemistry Laboratory	0-0-3	2
8	CS 171	Computing Laboratory – I	0-0-3	2
TOTAL				**25**

SECOND SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	LS 403	Immunology	3-1-0	4
2	LS 404	Molecular Biology and Biotechnology	3-1-0	4
3	LS 410	Food Science	3-1-0	4
4		Professional Elective – II	3-1-0	4
5		Open Elective – II	3-0-0	3
6	LS 473	Biotechnology Laboratory	0-0-3	2
7	LS 474	Molecular Biology Laboratory	0-0-3	2
8	LS 475	Immunology Laboratory	0-0-3	2
TOTAL				**25**

THIRD SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	LS 420	Applied Bioinformatics	3-1-0	4
2	LS 504	Environmental Sciences and Biostatistics	3-1-0	4
3	LS 512	Developmental Biology	3-1-0	4
4	LS 575	Applied Bioinformatics Laboratory	0-0-3	2
5	LS 591	Research Project – I	0-0-6	4
6		Professional Elective – III	3-1-0	4
7		Open Elective – III	3-0-0	3
8	LS 593	Seminar & Technical Writing – I	0-0-3	2
9	LS 595	Short-term Industrial/Research Experience (SIRE)	0-0-3	2
TOTAL				**29**

FOURTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	LS 511	Genetics	3-1-0	4
2	LS 592	Research Project – II	0-0-9	6
3	LS 594	Seminar & Technical Writing – II	0-0-3	2
4		Open Elective – IV	3-0-0	3
5		Professional Elective – IV	3-1-0	4
6	LS 596	Comprehensive Viva - Voce	0-0-0	2
TOTAL				**21**

TOTAL CREDITS: **25+25+29+21= 100**

LIST OF PROFESSIONAL ELECTIVES

Sl. No.	Sub.code	Subject	L-T-P	Credits
1.	LS 405	Cell biology	3-1-0	4
2.	LS 411	Biophysics	3-1-0	4
3.	LS 412	Advanced Microbial genetics	3-1-0	4
4.	LS 421	Radiation biology	3-1-0	4
5.	LS 422	Cell-cell Signaling	3-1-0	4
6.	LS 423	Advanced Techniques	3-1-0	4
7.	LS 424	Genomics & Proteomics	3-1-0	4
8.	LS 502	Advances in Structural Biology	3-1-0	4
9.	LS 505	Food Processing technology	3-1-0	4
10.	LS 513	Enzymology and metabolism	3-1-0	4
11.	LS 530	Aquatic biology and marine biotechnology	3-1-0	4
12.	LS 531	Epigenetics	3-1-0	4
13.	LS 532	Molecular medicine	3-1-0	4
14.	LS 536	RNAi, Stem cells & Oncogenomics	3-1-0	4
15.	LS 581	Cancer Biology	3-1-0	4
16.	LS 583	Special Topics in Modern Biology – I	3-1-0	4
17.	LS 584	Special Topics in Modern Biology – II	3-1-0	4
18.	LS 585	Special Topics in Applied Life Science – I	3-1-0	4
19.	LS 586	Special Topics in Applied Life Science – II	3-1-0	4

LIST OF OPEN ELECTIVES

Sl. No	Sub.Code	Subject	L-T-P	Credits	Non Eligible Branches
1.	LS 406	Fundamentals of Cell Biology	3-0-0	3	HS, SM
2.	LS 413	Basic Biophysics	3-0-0	3	HS, SM
3.	LS 414	Microbial Genetics	3-0-0	3	HS, SM
4.	LS 425	Introduction to Bioinformatics	3-0-0	3	HS, SM
5.	LS 427	Advanced Techniques	3-0-0	3	HS, SM
6.	LS 435	Microbial Diversity and Extremophiles	3-0-0	3	HS, SM
7.	LS 503	Recombinant DNA Technology	3-0-0	3	HS, SM
8.	LS 507	Structural Biology	3-0-0	3	HS, SM
9.	LS 509	Introduction to Proteomics	3-0-0	3	HS,SM
10.	LS 514	Fundamental of Genetics	3-0-0	3	HS, SM
11.	LS 533	Marine Biotechnology	3-0-0	3	HS, SM
12.	LS 534	Introduction to Epigenetics	3-0-0	3	HS, SM
13.	LS 535	Basics in Molecular Medicine	3-0-0	3	HS, SM
14.	LS 537	Processing of Food Commodities	3-0-0	3	-
15.	LS 538	Man and Microbes	3-0-0	3	CE, CS, EC,EE, ME,ID, FP, PA, EA, MM, MN,MA,HS, SM
16.	LS 539	Stem Cell and Regenerative Medicine	3-0-0	3	-
17.	LS 540	Research Methodology	3-0-0	3	HS, SM
18.	LS 542	Basic Biotechnology	3-0-0	3	-

SUMMARY OF COURSES

Sub Discipline: Foundation Courses

LS 401	Microbiology	3-1-0	4
LS 402	Biochemistry	3-1-0	4

LS 403	Immunology	3-1-0	4
LS 440	Physical Sciences and Instrumentation	3-1-0	4

Sub Discipline: Cell and Molecular Biology

LS 404	Molecular Biology and Biotechnology	3-1-0	4
LS 405	Cell biology	3-1-0	4
LS 406	Fundamentals of Cell Biology	3-0-0	3
LS 502	Advances in Structural Biology	3-1-0	4
LS 503	Recombinant DNA Technology	3-0-0	3
LS 507	Structural Biology	3-0-0	3

Sub Discipline: Topics in Modern Biology

LS 410	Food Science	3-1-0	4
LS 411	Biophysics	3-1-0	4
LS 412	Advanced Microbial genetics	3-1-0	4
LS 413	Basic Biophysics	3-0-0	3
LS 414	Microbial Genetics	3-0-0	3
LS 504	Environmental Sciences and Biostatistics	3-1-0	4
LS 511	Genetics	3-1-0	4
LS 512	Developmental Biology	3-1-0	4
LS 513	Enzymology & Metabolism	3-1-0	4
LS 514	Fundamental of Genetics	3-0-0	3
LS 537	Processing of Food Commodities	3-0-0	3
LS 538	Man and Microbes	3-0-0	3

Sub Discipline: Advanced Courses

LS 420	Applied Bioinformatics	3-1-0	4
LS 421	Radiation biology	3-1-0	4
LS 422	Cell – cell signaling	3-1-0	4
LS 423	Advanced Techniques	3-1-0	4
LS 424	Genomics and Proteomics	3-1-0	4
LS 425	Introduction to Bioinformatics	3-0-0	3
LS 427	Advanced Techniques	3-0-0	3
LS 509	Introduction to Proteomics	3-0-0	3
LS 539	Stem Cell and Regenerative Medicine	3-0-0	3
LS 542	Basic Biotechnology	3-0-0	3

Sub Discipline: Specialized Courses

LS 435	Microbial Diversity and Extremophiles	3-0-0	3
LS 505	Food Processing Technology	3-1-0	4
LS 530	Aquatic biology and marine biotechnology	3-1-0	4
LS 531	Epigenetics	3-1-0	4
LS 532	Molecular medicine	3-1-0	4
LS 533	Marine biotechnology	3-0-0	3
LS 534	Introduction to Epigenetics	3-0-0	3
LS 535	Basics in Molecular medicine	3-0-0	3
LS 536	RNAi, Stem cells and Oncogenomics	3-1-0	4
LS 581	Cancer Biology	3-1-0	4

Sub Discipline: Research Methodology

LS 540	Research Methodology	3-0-0	3

Sub Discipline: Laboratory Courses

CS 171	Computing Laboratory – I	0-0-3	2
LS 471	Microbiology Laboratory	0-0-3	2
LS 472	Biochemistry Laboratory	0-0-3	2
LS 473	Biotechnology Laboratory	0-0-3	2
LS 474	Molecular Biology Laboratory	0-0-3	2
LS 475	Immunology Laboratory	0-0-3	2
LS 575	Applied Bioinformatics Laboratory	0-0-3	2

Sub Discipline: Project Seminar and Special Courses

LS 583	Special Topics in Modern Biology – I	3-1-0	4
LS 584	Special Topics in Modern Biology – II	3-1-0	4
LS 585	Special Topics in Applied Life Science – I	3-1-0	4
LS 586	Special Topics in Applied Life Science – II	3-1-0	4
LS 591	Research Project – I	0-0-6	4
LS 592	Research Project – II	0-0-9	6
LS 593	Seminar and Technical writing– I	0-0-3	2
LS 594	Seminar and Technical writing– II	0-0-3	2
LS 595	Short-term Industrial/Research Experience (SIRE)	0-0-3	2
LS 596	Comprehensive Viva – Voce	0-0-0	2

DEPARTMENT OF MATHEMATICS

Curriculum of M.Sc (MATHEMATICS)

FIRST SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credit
1	MA 401	Real Analysis	3-1-0	4
2	MA 403	Linear Algebra	3-1-0	4
3	MA 405	Partial Differential Equations	3-1-0	4
4	MA 407	Topology	3-1-0	4
5		Open Elective – I	3-0-0	3
6	MA 471	Object Oriented Programming Practice Laboratory	0-0-3	2
7	MA 481	Departmental Seminar – I	0-0-3	2
TOTAL				**23**

SECOND SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credit
1	MA 402	Measure Theory	3-1-0	4
2	MA 404	Functions of a Complex Variable	3-1-0	4
3		Professional Elective – I	3-1-0	4
4		Professional Elective – II	3-1-0	4
5		Open Elective – II	3-0-0	3
6	MA 470	Laboratory works on Real Life Problems – I	0-0-3	2
7	MA 472	Research Paper Review	0-0-3	2
8	MA 482	Departmental Seminar – II	0-0-3	2
TOTAL				**25**

THIRD SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credit
1	MA 501	Abstract Algebra	3-1-0	4
2		Professional Elective – III	3-1-0	4
3		Professional Elective – IV	3-1-0	4
4		Open Elective – III	3-0-0	3
5	MA 571	Statistical Methods Laboratory	0-0-3	2
6	MA 591	Research Project – I	0-0-6	4
7	MA 593	Seminar & Technical Writing – I	0-0-3	2
8	MA 595	Short term Industrial/Research Experience	0-0-3	2
TOTAL				**25**

FOURTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credit
1	MA 502	Functional Analysis	3-1-0	4
2		Professional Elective – V	3-1-0	4
3		Professional Elective – VI	3-1-0	4
4		Open Elective – IV	3-0-0	3
5	MA 572	Laboratory Works on Real Life Problems – II	0-0-3	2
6	MA 592	Research Project – II	0-0-9	6
7	MA 594	Seminar & Technical Writing – II	0-0-3	2
8	MA 596	Comprehensive Viva Voce	0-0-3	2
TOTAL				**28**

Curriculum of Integrated M.Sc. (MATHEMATICS)

FIRST SEMESTER(STRUCTURE COMMON TO ALL BRANCHES)

Sl.No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Differential Equations		3-1-0	4
2	PH 101	Physics – I		3-1-0	4
3	CY 101	Chemistry		3-1-0	4
4	EE 100	Basic Electrical Technology	OR	3-1-0	4
	EC 100	Basic Electronics Engineering			
5	CE 100	Engineering Mechanics	OR	3-1-0	4
	CE 130	Environmental and Safety Engineering			
6	PH 170	Physics Laboratory	OR	0-0-3	2
	CY 170	Chemistry Laboratory			
7	CS 171	Computing Laboratory – I		0-0-3	2
8	CE 171	Engineering Drawing		0-0-3	2
9	WS 171	Workshop Practice – I		0-0-3	2
10		Extra Academic Activity – I		0-0-3	2
TOTAL					**30**

SECOND SEMESTER(STRUCTURE COMMON TO ALL BRANCHES)

Sl.No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Matrix theory, Vector Calculus and Fourier Analysis		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithms		3-1-0	4
4	EC 100	Basic Electronics Engineering	OR	3-1-0	4
	EE 100	Basic Electrical Technology			
5	CE 130	Environmental and Safety Engineering	OR	3-1-0	4
	CE 100	Engineering Mechanics			
6	CY 170	Chemistry Laboratory	OR	0-0-3	2
	PH 170	Physics Laboratory			
7	CS 172	Computing Laboratory – II		0-0-3	2
8	ME 170	Machine Drawing and Solid Modeling		0-0-3	2
9	ME 172	Workshop Practice – II		0-0-3	2
10		Extra Academic Activity – I		0-0-3	2
TOTAL					**30**

THIRD SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credit
1	MA 205	Calculus	3-1-0	4
2	MA 207	Introduction to Numerical Analysis	3-1-0	4
3	CY 221	Chemistry of Industrial Materials	3-1-0	4
4	PH 201	Heat and Thermodynamics	3-1-0	4
5		Open Elective-I	3-0-0	3
6	CY 271	UG Organic Chemistry Laboratory	0-0-3	2
7	PH 271	Thermal Laboratory	0-0-3	2
8	MA 270	Numerical Methods Laboratory	0-0-3	2
9	EE 270/	Electrical Engineering Laboratory/Electronics Laboratory	0-0-3	2
TOTAL				**27**

FOURTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credit
1	MA 206	Introduction to Complex Analysis and Partial Differential Equations	3-1-0	4
2	MA 208	Analysis – I	3-1-0	4
3	CY 214	Basic Organic Chemistry – I	3-1-0	4
4	PH 202	Electricity and Magnetism	3-1-0	4
5		Open Elective-II	3-0-0	3
6	CY 273	UG Physical Chemistry Laboratory	0-0-3	2
7	PH 272	Electricity and Magnetism Laboratory	0-0-3	2
8	HS 270	Language Laboratory	0-0-3	2
TOTAL				**25**

FIFTH SEMESTER

Sl. No.	Sub. Code	Subject	L-T-P	Credit
1	MA 301	Group Theory	3-1-0	4
2	MA 321	Discrete Mathematics	3-1-0	4
3	CY 321	Basic Physical Chemistry	3-1-0	4
4	PH 301	Waves and Applications	3-1-0	4
5		Open Elective – III	3-0-0	3
6	CY 375	Instrumentation Laboratory	0-0-3	2
7	PH 371	Waves and Optics Laboratory	0-0-3	2
8	MA 373	Laboratory works on Latex and Matlab	0-0-3	2
TOTAL				**25**

SIXTH SEMESTER

Sl. No.	Sub. Code	Subject	L-T-P	Credit
1	MA 322	Linear Programming	3-1-0	4
2	MA 332	Probability	3-1-0	4
3	CY 322	Basic Inorganic Chemistry – I	3-1-0	4
4	PH 302	Properties of Matter	3-1-0	4
5		Open Elective – IV	3-0-0	3
6	CY 374	Inorganic Chemistry Laboratory	0-0-3	2
7	MA 372	Statistics Laboratory	0-0-3	2
8	PH 374	Properties of Matter Laboratory	0-0-3	2
TOTAL				**25**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credit
1	MA 403	Linear Algebra	3-1-0	4
2	MA 413	Analysis – II	3-1-0	4
3	MA 405	Partial Differential Equations	3-1-0	4
4	MA 407	Topology	3-1-0	4
5		Open Elective – V	3-0-0	3
6	MA 471	Object Oriented Programming Practice Laboratory	0-0-3	2
7	MA 481	Departmental Seminar – I	0-0-3	2
TOTAL				**23**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credit
1	MA 402	Measure Theory	3-1-0	4
2	MA 404	Functions of a Complex Variable	3-1-0	4
3		Professional Elective – I	3-1-0	4
4		Professional Elective – II	3-1-0	4
5		Open Elective – VI	3-0-0	3
6	MA 470	Laboratory works on Real Life Problems – I	0-0-3	2
7	MA 472	Research Paper Review	0-0-3	2
8	MA 482	Departmental Seminar – II	0-0-3	2
TOTAL				**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credit
1	MA 503	Theory of Rings and Fields	3-1-0	4
2		Professional Elective – III	3-1-0	4
3		Professional Elective – IV	3-1-0	4
4		Open Elective – VII	3-0-0	3
5	MA 571	Statistics Methods Laboratory	0-0-3	2
6	MA 591	Research Project – I	0-0-6	4
7	MA 593	Seminar & Technical Writing – I	0-0-3	2
8	MA 595	Short Term Industrial/Research Experience	0-0-0	2
TOTAL				**25**

TENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credit
1	MA 502	Functional Analysis	3-1-0	4
2		Professional Elective – V	3-1-0	4
3		Professional Elective – VI	3-1-0	4
4		Open Elective – VIII	3-0-0	3
5	MA 572	Laboratory Works on Real Life Problems – II	0-0-3	2
6	MA 592	Research Project – II	0-0-9	6
7	MA 594	Seminar & Technical Writing – II	0-0-3	2
8	MA 596	Comprehensive Viva Voce	0-0-3	2
TOTAL				**27**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Subject	Subject	L-T-P	Credit
1	MA 438	Dynamical Systems	3-1-0	4
2	MA 504	Introduction to Several Complex Variables	3-1-0	4
3	MA 510	Calculus of Several Variables	3-1-0	4
4	MA 511	Differential Geometry	3-1-0	4
5	MA 512	Fourier Analysis	3-1-0	4
6	MA 513	Differential Topology	3-1-0	4
7	MA 514	Rings and Module	3-1-0	4
8	MA 515	Homotopy Theory	3-1-0	4
9	MA 516	Operator Theory	3-1-0	4
10	MA 517	Lie Algebra	3-1-0	4
11	MA 518	Advanced Complex Analysis	3-1-0	4
12	MA 519	Multi-Linear Algebra	3-1-0	4
13	MA 520	Automata Theory	3-1-0	4
14	MA 521	Combinatorics	3-1-0	4
15	MA 522	Operations Research	3-1-0	4

16	MA 523	Discrete Mathematics	3-1-0	4
17	MA 524	Statistical Methods	3-1-0	4
18	MA 525	Ergodic Theory	3-1-0	4
19	MA 527	Fractals	3-1-0	4
20	MA 529	Information Theory	3-1-0	4
21	MA 531	Boundary Layer Theory	3-1-0	4
22	MA 532	Numerical Solutions of Partial Differential Equations	3-1-0	4
23	MA 533	Modern Theory of Partial Differential Equations	3-1-0	4
24	MA 534	Geometry of Robotics	3-1-0	4
25	MA 535	Calculus of Variations and Integral Equations	3-1-0	4
26	MA 536	Numerical Method for Differential Equation	3-1-0	4
27	MA 537	Numerics of Singularly Perturbed Differential Equation	3-1-0	4
28	MA 538	Fluid Dynamics	3-1-0	4
29	MA 539	Scientific Computing	3-1-0	4
30	MA 540	Singular Homology Theory	3-1-0	4
31	MA 541	Commutative Algebra	3-1-0	4
32	MA 542	Tensor Analysis	3-1-0	4
33	MA 543	Complex Dynamics	3-1-0	4
34	MA 544	Category Theory	3-1-0	4
35	MA 545	Convex Analysis and Monotone Operator	3-1-0	4
36	MA 546	Differentiable Manifolds	3-1-0	4
37	MA 547	Geometry of Normed Spaces	3-1-0	4
38	MA 548	Field Theory	3-1-0	4
39	MA 549	Algebraic Geometry	3-1-0	4
40	MA 550	Coding Theory	3-1-0	4
41	MA 551	Numerical Analysis	3-1-0	4
42	MA 552	Fuzzy Logic and Set Theory	3-1-0	4
43	MA 553	Optimization Techniques	3-1-0	4
44	MA 554	Graph Theory with Algorithms	3-1-0	4
45	MA 555	Stochastic Processes	3-1-0	4
46	MA 556	Number Theory	3-1-0	4
47	MA 557	Statistical Inference	3-1-0	4
48	MA 558	Sampling Techniques	3-1-0	4
49	MA 559	Statistical Decision Theory	3-1-0	4
50	MA 560	Mathematical Methods	3-1-0	4
51	MA 561	Lie Groups & Applications to ODEs & PDEs	3-1-0	4
52	MA 562	Finite Volume Methods for Hyperbolic PDEs	3-1-0	4
53	MA 563	Wavelets and Applications	3-1-0	4
54	MA 564	Integral and DiscreteTransforms	3-1-0	4
55	MA 565	Fractional Order Calculus	3-1-0	4
56	MA 566	Fractional Differential Equations and Fractional Order Models	3-1-0	4
57	MA 567	Theory of Vibrations	3-1-0	4
58	MA 568	Mathematics of Soft Computing	3-1-0	4

59	MA 569	Perturbation Methods	3-1-0	4

LIST OF PROFESSIONAL ELECTIVES OFFERED BY OTHER DEPARTMENTS

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1.	CS 414	Software Project, Process and Quality Management	3-1-0	4
2.	CS 418	Real Time Systems	3-1-0	4
3.	CS 425	Data Mining and Data Warehousing	3-1-0	4
4.	CS 427	Network Security	3-1-0	4
5.	CS 430	Information Theory and Coding	3-1-0	4
6.	CS 432	Distributed Operating Systems	3-1-0	4
7.	CS 438	Pattern Recognition	3-1-0	4
8.	CS 441	Advanced Computer Architecture	3-1-0	4
9.	CS 443	Embedded Systems	3-1-0	4
10.	CS 444	Cluster and Grid Computing	3-1-0	4
11.	CS 445	Parallel Algorithms	3-1-0	4
12.	CS 613	Combinatorial Optimization	3-1-0	4
13.	CS 617	Graph Theory and Network Algorithms	3-1-0	4
14.	CS 621	Cryptographic Foundations	3-1-0	4
15.	CS 630	Artificial Intelligence	3-1-0	4
16.	CS 631	Information Theory and Coding	3-1-0	4
17.	CS 633	Game Theory	3-1-0	4
18.	CS 635	Biometric Security	3-1-0	4
19.	CS 638	Image Processing	3-1-0	4
20.	CS 639	Soft Computing	3-1-0	4
21.	CS 673	Image Processing Laboratory	0-0-3	2
22.	CS 675	Soft Computing Laboratory	0-0-3	2
23.	CS 676	Cryptographic Laboratory – I	0-0-3	2
24.	CS 679	Network Security Lab	0-0-3	2
25.	EC 641	Digital Signal Processing	3-1-0	4
26.	EC 644	Soft Computing	3-1-0	4

Note: all courses are common to both M.Sc and Integrated M.Sc

LIST OF OPEN ELECTIVES

Sl. No	Sub. Code	Subject	L-T-P	Credits	Non Eligible Branches
1.	MA 311	Linear Algebra	3-0-0	3	-
2.	MA 312	Real Analysis	3-0-0	3	-
3.	MA 313	Complex Analysis and Transforms Techniques	3-0-0	3	
3.	MA 411	Metric Spaces	3-0-0	3	-
4.	MA 423	Discrete Mathematics	3-0-0	3	-
5.	MA 424	Operations Research	3-0-0	3	-
6.	MA 426	Elementary Stochastic Processes with Applications	3-0-0	3	-
7.	MA 431	Mathematical Methods	3-0-0	3	-
8.	MA 432	Finite Difference Methods	3-0-0	3	-
9.	MA 433	Finite Element Methods	3-0-0	3	-

SUMMARY OF COURSES

Sub Discipline: Foundation Courses

MA 101	Differential Equations	3-1-0	4
MA 102	Matrix theory, Vector Calculus and Fourier Analysis	3-1-0	4
MA 201	Probability, Statistics and Numerical Methods	3-1-0	4
MA 202	Complex Analysis and Partial Differential Equations	3-1-0	4
MA 205	Calculus	3-1-0	4
MA 206	Introduction to Complex Analysis and Partial Differential Equations	3-1-0	4
MA 207	Introduction to Numerical Analysis	3-1-0	4
MA 208	Analysis-I	3-1-0	4
MA 301	Group Theory	3-1-0	4
MA 321	Discrete Mathematics	3-1-0	4
MA 322	Linear Programming	3-1-0	4
MA 401	Real Analysis	3-1-0	4
MA 402	Measure Theory	3-1-0	4
MA 403	Linear Algebra	3-1-0	4
MA 404	Functions of a Complex Variable	3-1-0	4
MA 405	Partial Differential Equations	3-1-0	4
MA 407	Topology	3-1-0	4
MA 413	Analysis-II	3-1-0	4
MA 501	Abstract Algebra	3-1-0	4
MA 502	Functional Analysis	3-1-0	4
MA 503	Theory of Rings and Fields	3-1-0	4

Sub Discipline: Topology, Analysis and Algebra

MA 311	Linear Algebra	3-0-0	3
MA 312	Real Analysis	3-0-0	3
MA 313	Complex Analysis and Transforms Techniques	3-0-0	3
MA 504	Introduction to Several Complex Variables	3-1-0	4
MA 510	Calculus of Several Variables	3-1-0	4
MA 511	Differential Geometry	3-1-0	4
MA 512	Fourier Analysis	3-1-0	4
MA 513	Differential Topology	3-1-0	4
MA 514	Rings and Modules	3-1-0	4
MA 515	Homotopy Theory	3-1-0	4
MA 516	Operator Theory	3-1-0	4
MA 517	Lie Algebra	3-1-0	4
MA 518	Advanced Complex Analysis	3-1-0	4
MA 519	Multi-Linear Algebra	3-1-0	4
MA 540	Singular Homology Theory	3-1-0	4
MA 541	Commutative Algebra	3-1-0	4
MA 542	Tensor Analysis	3-1-0	4
MA 543	Complex Dynamics	3-1-0	4
MA 544	Category Theory	3-1-0	4
MA 545	Convex Analysis and Monotone Operator	3-1-0	4
MA 546	Differentiable Manifolds	3-1-0	4
MA 547	Geometry of Normed Spaces	3-1-0	4
MA 548	Field Theory	3-1-0	4
MA 549	Algebraic Geometry	3-1-0	4

Sub Discipline: Statistics and Optimization

MA 423	Discrete Mathematics	3-0-0	3
MA 424	Operations Research	3-0-0	3
MA 426	Elementary Stochastic Processes with Applications	3-0-0	3
MA 520	Automata Theory	3-1-0	4
MA 521	Combinatorics	3-1-0	4
MA 522	Operations Research	3-1-0	4
MA 523	Discrete Mathematics	3-1-0	4
MA 524	Statistical Methods	3-1-0	4
MA 525	Ergodic Theory	3-1-0	4
MA 527	Fractals	3-1-0	4
MA 529	Information Theory	3-1-0	4
MA 550	Coding Theory	3-1-0	4
MA 551	Numerical Analysis	3-1-0	4
MA 552	Fuzzy Logic and Set Theory	3-1-0	4
MA 553	Optimization Techniques	3-1-0	4
MA 554	Graph Theory with Algorithms	3-1-0	4
MA 555	Stochastic Processes	3-1-0	4
MA 556	Number Theory	3-1-0	4
MA 557	Statistical Inference	3-1-0	4
MA 558	Sampling Techniques	3-1-0	4
MA 559	Statistical Decision Theory	3-1-0	4

Sub Discipline: Applied Mathematics

MA 431	Mathematical Methods	3-0-0	3
MA 432	Finite Difference Methods	3-0-0	3
MA 433	Finite Element Methods	3-0-0	3
MA 438	Dynamical Systems	3-1-0	4
MA 531	Boundary Layer Theory	3-1-0	4
MA 532	Numerical Solutions of Partial Differential Equations	3-1-0	4
MA 533	Modern Theory of Partial Differential Equations	3-1-0	4
MA 534	Geometry of Robotics	3-1-0	4
MA 535	Calculus of Variations and Integral Equations	3-1-0	4
MA 536	Numerical Methods for Differential Equations	3-1-0	4
MA 537	Numerics of Singularly Perturbed Differential Equations	3-1-0	4
MA 538	Fluid Dynamics	3-1-0	4
MA 539	Scientific Computing	3-1-0	4
MA 560	Mathematical Methods	3-1-0	4
MA 561	Lie Groups & Applications to ODEs & PDEs	3-1-0	4
MA 562	Finite Volume Methods for Hyperbolic PDEs	3-1-0	4
MA 563	Wavelets and Applications	3-1-0	4
MA 564	Integral Transforms	3-1-0	4
MA 565	Fractional Order Calculus	3-1-0	4
MA 566	Fractional Differential Equations and Fractional Order Models	3-1-0	4
MA 567	Theory of Vibrations	3-1-0	4
MA 568	Mathematics of Soft Computing	3-1-0	4

Sub Discipline: Laboratory Courses

MA 270	Numerical Methods Laboratory	0-0-3	2
MA 372	Stastics Laboratory	0-0-3	2
MA 373	Laboratory Works on Latex and Matlab	0-0-3	2
MA 470	Laboratory works on Real Life Problems – I	0-0-3	2

MA 471	Object Oriented Programming Practice Laboratory	0-0-3	2
MA 571	Statistical Methods Laboratory	0-0-3	2
MA 572	Laboratory Works on Real Life Problems – II	0-0-3	2
MA 574	Laboratory Works on NSPDE	0-0-3	2

Sub Discipline: Project, Seminar and Special Courses

MA 472	Research Paper Review	0-0-3	2
MA 481	Departmental Seminar – I	0-0-3	2
MA 482	Departmental Seminar – II	0-0-3	2
MA 591	Research Project – I	0-0-6	4
MA 592	Research Project – II	0-0-9	6
MA 593	Seminar & Technical Writing – I	0-0-3	2
MA 594	Seminar & Technical Writing – II	0-0-3	2
MA 595	Short term Industrial/Research Experience	0-0-3	2
MA 596	Comprehensive Viva Voce	0-0-3	2

DEPARTMENT OF PHYSICS

Curriculum of M.Sc (Physics)

FIRST SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	PH 401	Mathematical Methods in Physics	3-1-0	4
2	PH 403	Classical Mechanics	3-1-0	4
3	PH 405	Statistical Mechanics	3-1-0	4
4	PH 407	Quantum Mechanics – I	3-1-0	4
5	EC 100	Basic Electronics Engineering	3-1-0	4
6	PH 471	General Physics Laboratory	0-0-3	2
7	PH 473	Spectroscopy Laboratory	0-0-3	2
8	CS 171	Computing Laboratory – I	0-0-3	2
TOTAL				**26**

SECOND SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	PH 402	Numerical Techniques in Physics	3-1-0	4
2	PH 404	Electrodynamics	3-1-0	4
3	PH 406	Condensed Matter Physics	3-1-0	4
4	PH 408	Quantum Mechanics – II	3-1-0	4
5		Open Elective – I	3-0-0	3
6	PH 472	SolidState Physics Laboratory	0-0-3	2
7	EC 270	Basic Electronics Laboratory	0-0-3	2
8	CS 172	Computing Laboratory – II	0-0-3	2
TOTAL				**25**

THIRD SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	PH 507	Nuclear & Particle Physics	3-1-0	4
2		Open Elective – II	3-0-0	3
3		Professional Elective – I	3-1-0	4
4		Professional Elective – II	3-1-0	4
5	PH 571	Instrumentation Laboratory	0-0-3	2
6	PH 573	Computational Physics Laboratory	0-0-3	2
7	PH 591	Research Project – I	0-0-6	4
8	PH 593	Seminar & Technical Writing – I	0-0-3	2
9	PH 595	Short Term Industrial / Research Experience	0-0-0	2
TOTAL				**27**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	PH 508	Atomic & Molecular Physics	3-1-0	4
2		Open Elective – III	3-0-0	3
3		Professional Elective – III	3-1-0	4
4		Professional Elective – IV	3-1-0	4
5	PH 572	Advanced Materials Synthesis Laboratory	0-0-3	2
6	PH 574	Advanced Characterization Techniques Laboratory	0-0-3	2
7	PH 592	Research Project – II	0-0-9	6
8	PH 594	Seminar & Technical Writing – II	0-0-3	2
9	PH 596	Comprehensive Viva – Voice	0-0-0	2
TOTAL				**29**

Curriculum of Integrated M.Sc. (PHYSICS)

FIRST SEMESTER(STRUCTURE COMMON TO ALL BRANCHES)

Sl.No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Differential Equations		3-1-0	4
2	PH 101	Physics – I		3-1-0	4
3	CY 101	Chemistry		3-1-0	4
4	EE 100	Basic Electrical Technology	OR	3-1-0	4
	EC 100	Basic Electronics Engineering			
5	CE 100	Engineering Mechanics	OR	3-1-0	4
	CE 130	Environmental and Safety Engineering			
6	PH 170	Physics Laboratory	OR	0-0-3	2
	CY 170	Chemistry Laboratory			
7	CS 171	Computing Laboratory – I		0-0-3	2
8	CE 171	Engineering Drawing		0-0-3	2
9	WS 171	Workshop Practice – I		0-0-3	2
10		Extra Academic Activity – I		0-0-3	2
TOTAL					**30**

SECOND SEMESTER(STRUCTURE COMMON TO ALL BRANCHES)

Sl.No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Matrix theory, Vector Calculus and Fourier Analysis		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithms		3-1-0	4
4	EC 100	Basic Electronics Engineering	OR	3-1-0	4
	EE 100	Basic Electrical Technology			
5	CE 130	Environmental and Safety Engineering	OR	3-1-0	4
	CE 100	Engineering Mechanics			
6	CY 170	Chemistry Laboratory	OR	0-0-3	2
	PH 170	Physics Laboratory			
7	CS 172	Computing Laboratory – II		0-0-3	2
8	ME 170	Machine Drawing and Solid Modeling		0-0-3	2
9	WS 172	Workshop Practice – II		0-0-3	2
10		Extra Academic Activity – I		0-0-3	2
TOTAL					**30**

THIRD SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1.	PH 201	Thermodynamics	3-1-0	4
2.	EC 201	Analog Electronics	3-1-0	4
3.	CY 221	Chemistry of Industrial Materials	3-1-0	4
4.	MA 207	Introduction to Numerical Analysis	3-1-0	4
5.		Open Elective – I	3-0-0	3
6.	PH 271	Thermal Laboratory	0-0-3	2
7.	CY 271	UG Organic Chemistry Laboratory	0-0-3	2
8.	MA 270	Numerical Methods Laboratory	0-0-3	2
TOTAL				**25**

FOURTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1.	PH 202	Electricity & Magnetism	3-1-0	4
2.	EC 202	Digital Electronics	3-0-0	3
3.	CY 214	Basic Organic Chemistry – I	3-1-0	4

4.	MA 206	Introduction to Complex Analysis and Partial Differential Equations	3-1-0	4
5.		Open Elective – II	3-0-0	3
6.	PH 272	Electricity & Magnetism Laboratory	0-0-3	2
7.	CY 273	UG Physical Chemistry Laboratory	0-0-3	2
8.	HS 270	Language Laboratory	0-0-3	2
TOTAL				**24**

FIFTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1.	PH 301	Wave and Oscillations	3-1-0	4
2.	PH 303	Optics	3-1-0	4
3.	CY 231	Basic Physical Chemistry – I	3-1-0	4
4.	MA 301	Group Theory	3-1-0	4
5.		Open Electives – III	3-0-0	3
6.	PH 371	Waves and Optics Laboratory	0-0-3	2
7.	CY 375	Instrumentation Laboratory	0-0-3	2
8.	MA 373	Laboratory Works on Latex and Matlab	0-0-3	2
TOTAL				**25**

SIXTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1.	PH 302	Properties of Matter	3-1-0	4
2.	PH 304	Introduction to Mechanics	3-1-0	4
3.	CY 322	Basic Inorganic Chemistry – I	3-1-0	4
4.	MA 332	Probability	3-1-0	4
5.		Open Elective – IV	3-0-0	3
6.	PH 372	Properties of Matter Laboratory	0-0-3	2
7.	CY 374	UG Inorganics Chemistry Laboratory	0-0-3	2
8.	MA 372	Statistics Laboratory	0-0-3	2
TOTAL				**25**

SEVENTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1.	PH 401	Mathematical Methods in Physics	3-1-0	4
2.	PH 403	Classical Mechanics	3-1-0	4
3.	PH 405	Statistical Mechanics	3-1-0	4
4.	PH 407	Quantum Mechanics – I	3-1-0	4
5.	PH 409	Introduction to Spectroscopy	3-1-0	4
6.	PH 471	General Physics Laboratory	0-0-3	2
7.	PH 473	Spectroscopy Laboratory	0-0-3	2
8.	PH 481	Research Project – I	0-0-6	4
TOTAL				**28**

EIGHTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1.	PH 402	Numerical Techniques in Physics	3-1-0	4
2.	PH 404	Electrodynamics	3-1-0	4
3.	PH 408	Quantum Mechanics – II	3-1-0	4
4.	PH 406	Condensed Matter Physics	3-1-0	4
5.		Open Elective – V	3-0-0	3
6.	PH 472	Solid State Physics Laboratory	0-0-3	2
7.	EC 270	Basic Electronics Laboratory	0-0-3	2
8.	PH 482	Research Project – II	0-0-6	4

TOTAL				27

NINTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1.	PH 507	Nuclear & Particle Physics	3-1-0	4
2.		Professional Elective – I	3-1-0	4
3.		Professional Elective – II	3-1-0	4
4.	PH 571	Instrumentation Laboratory	0-0-3	2
5.	PH 573	Computational Physics Laboratory	0-0-3	2
6.	PH 581	Research Project – III	0-0-6	4
7.	PH 593	Seminar & Technical Writing – I	0-0-3	2
8.	PH 595	Short Term Industrial/Research Experience	0-0-0	2
TOTAL				**27**

TENTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T-P	Credits
1	PH 508	Atomic & Molecular Physics	3-1-0	4
2		Professional Elective – III	3-1-0	4
3		Professional Elective – IV	3-1-0	4
4		Open Elective – VII	3-0-0	3
5	PH 572	Advanced material synthesis Laboratory	0-0-3	2
6	PH 574	Advanced Characterization Techniques Laboratory	0-0-3	2
7	PH 582	Research Project – IV	0-0-9	6
8	PH 594	Seminar & Technical Writing – II	0-0-3	2
9	PH 596	Comprehensive Viva Voce	0-0-0	2
TOTAL				**29**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subjects	L-T-P	Credits	Offered to
1	PH 511	Advanced Quantum Mechanics	3-1-0	4	#
2	PH 512	Advanced Statistical Mechanics	3-1-0	4	#
3	PH 513	Density Functional Theory and its recent applications	3-1-0	4	#
4	PH 514	Advanced Condensed Matter Physics	3-1-0	4	#
5	PH 522	Physics of Semiconductors : From Bulk to Quantum Dots	3-1-0	4	#
6	PH 523	Semiconductor Spintronics & Quantum Computation	3-1-0	4	#
7	PH 524	Computational Condensed Matter Physics	3-1-0	4	#
8	PH 525	Electronic Structure of Disordered Alloys	3-1-0	4	#
9	PH 531	Non – linear dynamics, Chaos and its recent applications	3-1-0	4	#
10	PH 532	Physics of Macromolecules	3-1-0	4	#
11	PH 533	Synchronization and its recent applications in Chaotic systems	3-0-0	3	#
12	PH 535	LASER Physics	3-1-0	4	#
13	PH 538	Special Topics in Condensed Matter Physics – I	3-1-0	4	#
14	PH 539	Special Topics in Condensed Matter Physics – II	3-1-0	4	#
15	PH 541	Dielectric & Magnetic Properties of Materials	3-1-0	4	#
16	PH 542	Physics & Applications of Dielectric Materials	3-1-0	4	#
17	PH 543	Bio-Ceramic Materials & Applications	3-1-0	4	#
18	PH 544	Polymer Physics	3-1-0	4	#

19	PH 551	Crystal Symmetry & Crystal Physics	3-1-0	4	#
20	PH 553	Advanced X-rays structure Analysis	3-1-0	4	#
21	PH 554	Physics of Thin film Technology	3-1-0	4	#
22	PH 555	Physics of Material Synthesis and Characterization	3-1-0	4	#
23	PH 556	X-rays and Nano Science	3-1-0	4	#
24	PH 561	Physics of Microelectronic and Photonic Devices	3-1-0	4	#
25	PH 562	Super fluidity and Superconductivity	3-1-0	4	#
26	PH 563	Physical Phenomena at Low Temperature	3-1-0	4	#
27	PH 564	Magnetism – Principles & Applications	3-1-0	4	#
28	PH 565	Defects in Solids	3-1-0	4	#
29	PH 568	Special Topics in Low Temperature Physics – I	3-1-0	4	#
30	PH 569	Special Topics in Low Temperature Physics – II	3-1-0	4	#
31	PH 381	Special Topics in Physics – I	3-1-0	4	$
32	PH 382	Special Topics in Physics – II	3-1-0	4	$
33	PH 383	Special Laboratory in Physics – I	0-0-3	2	$
34	PH 384	Special Laboratory in Physics – II	0-0-3	2	$

Note: $- for only Integrated MSc Courses

#- for both MSc and Integrated MSc Courses

PROFESSIONAL ELECTIVES FROM OTHER DEPARTMENTS

1	CH 419	Computational Fluid Dynamics	3-1-0	4
2	CR 415	Bio-ceramics	3-0-0	3
3	CR 424	Composite Materials	3-0-0	3
4	CR 435	Functional Materials & Devices	3-0-0	3
5	CR 441	Electrical and Magnetic Ceramics	3-1-0	4
6	CR 446	Thin Film and Coating	3-0-0	3
7	CS 430	Information Theory and Coding	3-1-0	4
8	CS 434	Image Processing	3-0-0	3
9	CS 438	Pattern Recognition	3-1-0	4
10	CS 444	Cluster and Grid Computing	3-1-0	4
11	CS 445	Parallel Algorithms	3-1-0	4
12	EE 404	Renewable Energy Systems	3-0-0	3
13	MM 448	Composite Materials	3-1-0	4
14	MM 442	Advanced Materials	3-0-0	3
15	MM 449	Nanostructured Materials	3-0-0	3
16	EC 410	Antenna Engineering	3-0-0	3
17	EC 411	Coding Theory and Secure Communication	3-0-0	3
18	EC 412	Antenna Analysis and Synthesis	3-1-0	4
19	EC 414	Information Theory and Coding	3-1-0	4
20	CY 515	Spectroscopic Methods of Analysis	3-0-0	3
21	CY 524	Group Theory and Molecular Orbitals	3-0-0	3
22	CY 525	Advanced Co-ordination Chemistry	3-0-0	3
23	CY 535	Electrochemistry	3-0-0	3
24	CY 537	Advanced Solid State Chemistry	3-0-0	3
25	CY 544	Instrumental Methods of Analysis	3-0-0	3
26	CY 554	Molecular Spectroscopy	3-0-0	3
27	MA 510	Calculus of Several Variables	3-1-0	4
28	MA 511	Differential Geometry	3-1-0	4
29	MA 512	Fourier Analysis	3-1-0	4
30	MA 513	Differential Topology	3-1-0	4

31	MA 514	Rings and Modules	3-1-0	4
32	MA 515	Homotopy Theory	3-1-0	4
33	MA 516	Operator Theory	3-1-0	4
34	MA 517	Lie Algebra	3-1-0	4
35	MA 518	Advanced Complex Analysis	3-1-0	4
36	MA 519	Multi-Linear Algebra	3-1-0	4
37	MA 520	Automata Theory	3-1-0	4
38	MA 521	Combinatorics	3-1-0	4
39	MA 522	Operations Research	3-1-0	4
40	MA 523	Discrete Mathematics	3-1-0	4
41	MA 524	Statistical Methods	3-1-0	4
42	MA 525	Ergodic Theory	3-1-0	4
43	MA 527	Fractals	3-1-0	4
44	MA 529	Information Theory	3-1-0	4
45	MA 530	Computational Methods in Boundary Value Problems	3-1-0	4
46	MA 531	Boundary Layer Theory	3-1-0	4
47	MA 532	Numerical Solutions of Partial Differential Equations	3-1-0	4
48	MA 534	Geometry of Robotics	3-1-0	4
49	MA 540	Singular Homology Theory	3-1-0	4
50	MA 542	Tensor Analysis	3-1-0	4
51	MA 544	Category Theory	3-1-0	4
52	MA 546	Differentiable Manifolds	3-1-0	4
53	MA 548	Field Theory	3-1-0	4
54	MA 549	Algebraic Geometry	3-1-0	4
55	MA 550	Coding Theory	3-1-0	4
56	MA 551	Numerical Analysis	3-1-0	4
57	MA 552	Fuzzy Logic and Set Theory	3-1-0	4
58	MA 553	Optimization Techniques	3-1-0	4
59	MA 554	Graph Theory with Algorithms	3-1-0	4
60	MA 555	Stochastic Processes	3-1-0	4
61	MA 556	Number Theory	3-1-0	4
62	MA 558	Sampling Techniques	3-1-0	4

COURSES OFFERED AS OPEN ELECTIVES

Sl. No	Sub. Code	Subject	L-T-P	Credit	Non Eligible Branches
1	PH 311	Fundamentals of Thermal & Statistical Physics	3-0-0	3	-
2	PH 312	Physics of Quantum World	3-0-0	3	-
3	PH 321	Physics of Semiconducting Materials	3-0-0	3	-
4	PH 331	World of LASERS	3-0-0	3	-
5	PH 332	Physics of the Universe	3-0-0	3	-
6	PH 341	Treatise of Einstein Work and Beyond	3-0-0	3	-
7	PH 351	Science of Nano-materials	3-0-0	3	-
8	PH 352	X-Ray techniques for Structure Evaluation	3-0-0	3	-
9	PH 422	Theory & Simulation of Nanostructures	3-0-0	3	-
10	PH 431	Non-linear systems & Chaos	3-0-0	3	-
11	PH 462	Vacuum Science and Applications	3-0-0	3	-

SUMMARY OF COURSES

Sub Discipline: Core Course

PH 101	Physics – I	3-1-0	4
PH 102	Physics – II	3-1-0	4
PH 201	Heat and Thermodynamics	3-1-0	4
PH 202	Electricity & Magnetism	3-1-0	4
PH 301	Wave and Oscillations	3-1-0	4
PH 302	Properties of Matter	3-1-0	4
PH 303	Optics	3-1-0	4
PH 304	Introduction to Mechanics	3-1-0	4
PH 401	Mathematical Methods in Physics	3-1-0	4
PH 402	Numerical Techniques in Physics	3-1-0	4
PH 403	Classical Mechanics	3-1-0	4
PH 404	Electrodynamics	3-1-0	4
PH 405	Statistical Mechanics	3-1-0	4
PH 406	Condensed Matter Physics	3-1-0	4
PH 407	Quantum Mechanics – I	3-1-0	4
PH 408	Quantum Mechanics – II	3-1-0	4
PH 409	Introduction to Spectroscopy	3-1-0	4
PH 507	Nuclear & Particle Physics	3-1-0	4
PH 508	Atomic & Molecular Physics	3-1-0	4

Sub Discipline: Condensed Matter Physics

PH 311	Fundamentals of Thermal & Statistical Physics	3-0-0	3
PH 312	The Physics of Quantum World	3-0-0	3
PH 321	Physics of Semiconducting Materials	3-0-0	3
PH 422	Theory & Simulation of Nanostructures	3-0-0	3
PH 511	Advanced Quantum Mechanics	3-1-0	4
PH 512	Advanced Statistical Mechanics	3-1-0	4
PH 513	Density Functional Theory and its Recent Applications	3-1-0	4
PH 514	Advanced Condensed Matter Physics	3-1-0	4
PH 522	Physics of Semiconductors : From Bulk to Quantum Dots	3-1-0	4
PH 523	Semiconductor Spintronics & Quantum Computation	3-1-0	4
PH 524	Computational Condensed Matter Physics	3-1-0	4
PH 525	Electronic Structure of Disordered Alloys	3-1-0	4

Sub Discipline: Soft Condensed Matter Physics

PH 331	World of LASERS	3-0-0	3
PH 332	Physics of the Universe	3-0-0	3
PH 431	Non-linear systems & Chaos	3-0-0	3
PH 531	Non – linear dynamics, Chaos and its recent applications	3-1-0	4
PH 532	Physics of Macromolecules	3-1-0	4
PH 533	Synchronization and its recent applications in Chaotic Systems	3-0-0	3
PH 535	LASER Physics	3-1-0	4

Sub Discipline: Functional Materials

PH 341	Treatise of Einstein Work and Beyond	3-0-0	3
PH 541	Dielectric & Magnetic Properties of Materials	3-1-0	4
PH 542	Physics & Applications of Dielectric Materials	3-1-0	4
PH 543	Bio-Ceramic Materials & Applications	3-1-0	4
PH 544	Polymer Physics	3-1-0	4

Sub Discipline: Synthesis and Characterization

PH 351	Science of Nano materials	3-0-0	3
PH 352	X-Ray techniques for Structure Evaluation	3-1-0	4
PH 551	Crystal Symmetry & Crystal Physics	3-1-0	4
PH 553	Advanced X-rays structure analysis	3-1-0	4
PH 554	Physics of Thin Film Technology	3-1-0	4
PH 555	Physics of material synthesis & Charaterization	3-1-0	4
PH 556	X-rays and Nano-Science	3-1-0	4

Sub Discipline: Low Temperature Physics

PH 462	Vacuum Science and Applications	3-1-0	4
PH 561	Physics of Microelectronics and Photonic Devices	3-1-0	4
PH 562	Superfluidity and Superconductivity	3-1-0	4
PH 563	Physical Phenomena at Low Temperature	3-1-0	4
PH 564	Magnetism – Principles & Applications	3-1-0	4
PH 565	Defects in Solids	3-1-0	4

ub Discipline: Laboratory Courses

PH 170	Physics Laboratory	0-0-3	2
PH 271	Thermal Laboratory	0-0-3	2
PH 272	Electricity & Magnetism Laboratory	0-0-3	2
PH 371	Waves and Optics Laboratory	0-0-3	2
PH 372	Properties of Matter Laboratory	0-0-3	2
PH 471	General Physics Laboratory	0-0-3	2
PH 472	Solid State Physics Laboratory	0-0-3	2
PH 473	Spectroscopy Laboratory	0-0-3	2
PH 571	Instrumentation Laboratory	0-0-3	2
PH 572	Advanced material synthesis Laboratory	0-0-3	2
PH 573	Computational Physics Laboratory	0-0-3	2
PH 574	Advanced Characterization Techniques Laboratory	0-0-3	2

Sub Discipline: Project, Seminar and Special Courses

PH 481	Research Project – I	0-0-6	4
PH 482	Research Project – II	0-0-6	4
PH 538	Special Topics in Condensed Matter Physics – I	3-1-0	4
PH 539	Special Topics in Condensed Matter Physics – II	3-1-0	4
PH 558	Special Topics in Functional Materials – I	3-1-0	4
PH 559	Special Topics in Functional Materials – II	3-1-0	4
PH 568	Special Topics in Low Temperature Physics – I	3-1-0	4
PH 569	Special Topics in Low Temperature Physics – II	3-1-0	4
PH 381	Special Topics in Physics – I	3-1-0	4
PH 382	Special Topics in Physics – II	3-1-0	4
PH 383	Special Laboratory in Physics – I	0-0-3	2
PH 384	Special Laboratory in Physics – II	0-0-3	2
PH 581	Research Project – III	0-0-6	4
PH 582	Research Project – IV	0-0-9	6
PH 591	Research Project – I	0-0-6	4
PH 592	Research Project – II	0-0-9	6
PH 593	Seminar & Technical Writing – I	0-0-3	2
PH 594	Seminar & Technical Writing – II	0-0-3	2
PH 595	Short Term Industrial/Research Experience	0-0-0	2
PH 596	Comprehensive Viva Voce	0-0-0	2

DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCES

Curriculum for MA (DEVELOPMENT STUDIES)

FIRST SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	HS 511	Technical and Business Communication	3-1-0	4
2	HS 522	Social Psychology and its Application	3-1-0	4
3	HS 531	Social Institutions and Development	3-1-0	4
4	HS 541	Economics of Development	3-1-0	4
5	HS 543	Global Issues in Development	3-1-0	4
6		Open Elective – I	3-0-0	3
7	CS 171	Computing Laboratory – I	0-0-3	2
TOTAL				**25**

SECOND SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	HS 500	Research Methodology	3-1-0	4
2	HS 532	Planning and Policy: Issues in India	3-1-0	4
3	HS 533	Development: Social, Anthropological and Political Perspectives	3-1-0	4
4	HS 542	Poverty, Inequality and Human Development	3-1-0	4
5		Professional Elective – I	3-1-0	4
6		Open Elective – II	3-0-0	3
7	HS 572	Statistical Laboratory	0-0-3	2
TOTAL				**25**

THIRD SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	HS 535	Gender and Development	3-1-0	4
2		Professional Elective – II	3-1-0	4
3		Professional Elective – III	3-1-0	4
4		Open Elective – III	3-0-0	3
5	HS 570	Advanced Language Laboratory	0-0-6	4
6	HS 591	Research Project – I	0-0-6	4
7	HS 593	Seminar & Technical Writing – I	0-0-3	2
8	HS 595	Short Term Industrial/Research Experience	0-0-3	2
TOTAL				**27**

FOURTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	HS 534	Natural Resource Management and Sustainable Development	3-1-0	4
2	HS 544	Environment and Development	3-1-0	4
3		Professional Elective – IV	3-1-0	4
4		Open Elective – IV	3-0-0	3
5	HS 592	Research Project – II	0-0-9	6
6	HS 594	Seminar & Technical Writing – II	0-0-3	2
7	HS 596	Comprehensive Viva –Voce	0-0-3	2
TOTAL				**25**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	HS 501	Advanced Research Methodology	3-1-0	4
2	HS 512	Literary Foundations: Methods and Genres	3-1-0	4
3	HS 513	Post-Colonial Consciousness and Development	3-1-0	4
4	HS 514	Mapping the Other: Theories for Alterity	3-1-0	4
5	HS 515	History of Ideas: The Modern Period	3-1-0	4
6	HS 516	Introduction to Critical Theories	3-1-0	4
7	HS 523	Educational Psychology	3-1-0	4
8	HS 524	Cognitive Development and Assessment	3-1-0	4
9	HS 525	Psychometrics: Theory and Applications	3-1-0	4
10	HS 526	Clinical Paradigms, Psychological Disorders and Therapeutic Interventions	3-1-0	4
11	HS 527	Corporate Social Responsibility	3-1-0	4
12	HS 536	Trends and Issues in Tribal Studies	3-1-0	4
13	HS 537	Development Issues in Orissa	3-1-0	4
14	HS 538	Urban Governance and Development	3-1-0	4
15	HS 545	Indian Financial System	3-1-0	4
16	HS 546	Population Dynamics and Development	3-1-0	4
17	HS 548	Demographic Transition and Health Policies in Developing World	3-1-0	4
18	HS 549	Public Economics	3-1-0	4
19	HS 550	Theory of Money, Output and Employment	3-1-0	4
20	HS 551	Special Topics in Development Studies – II		¾
21	HS 552	Special Topics in Development Studies – III		¾
22	HS 553	Special Topics in Development Studies – IV		¾

LIST OF OPEN ELECTIVES

Sl. No.	Sub. Code	Subject	L-T-P	Credits
1	HS 311	Communicative English	3-0-0	3
2	HS 312	Creative Writing	3-0-0	3
3	HS 317	Introduction to the Structure of Modern English	3-0-0	3
4	HS 321	Organizational Behaviour	3-0-0	3
5	HS 327	Cognitive Science	3-0-0	3
6	HS 328	Sports Psychology	3-0-0	3
7	HS 330	Introduction to Indian Society and Development	3-0-0	3
8	HS 331	Sociology: The Science of Praxis	3-0-0	3
9	HS 340	Special Course in Economics	3-0-0	3
10	HS 341	Managerial Economics	3-0-0	3
11	HS 350	Contemporary Dance	3-0-0	3
12	HS 410	Literary Foundations: Methods and Genres	3-0-0	3
13	HS 411	Ethical Leadership and Literature	3-0-0	3
14	HS 418	Language and Writing	3-0-0	3
15	HS 420	Human Resource Management	3-0-0	3
16	HS 428	Psychometrics	3-0-0	3
17	HS 431	Special Course in Sociology	3-0-0	3
18	HS 440	Financial Markets and Institutions	3-0-0	3
19	HS 441	Special Course in Economics	3-0-0	3
20	HS 448	Health Economics and Policy	3-0-0	3

SUMMARY OF COURSES

Sub Discipline: Research Methodology

HS 500	Research Methodology	3-1-0	4
HS 501	Advanced Research Methodology	3-1-0	4
HS 516	Introduction to Critical Theories	3-1-0	4

Sub Discipline: English

HS 311	Communicative English	3-0-0	3
HS 312	Creative Writing	3-0-0	3
HS 317	Introduction to the Structure of Modern English	3-0-0	3
HS 410	Literary Foundations: Methods and Genres	3-0-0	3
HS 411	Ethical Leadership and Literature	3-0-0	3
HS 418	Language and Writing	3-0-0	3
HS 511	Technical and Business Communication	3-1-0	4
HS 512	Literary Foundations: Methods and Genres	3-1-0	4
HS 513	Post-Colonial Consciousness and Development	3-1-0	4
HS 514	Mapping the Other: Theories for Alterity	3-1-0	4
HS 515	History of Ideas: The Modern Period	3-1-0	4

Sub Discipline: Psychology

HS 321	Organizational Behaviour	3-0-0	3
HS 327	Cognitive Science	3-0-0	3
HS 328	Sports Psychology	3-0-0	3
HS 428	Psychometrics	3-0-0	3
HS 522	Social Psychology and Its Application	3-1-0	4
HS 523	Educational Psychology	3-1-0	4
HS 524	Cognitive Development and Assessment	3-1-0	4
HS 525	Psychometrics: Theory and Applications	3-1-0	4
HS 526	Clinical Paradigms, Psychological Disorders and Therapeutic Interventions	3-1-0	4
HS 527	Corporate Social Responsibility	3-1-0	4

Sub Discipline: Sociology

HS 330	Introduction to Indian Society and Development	3-0-0	3
HS 331	Sociology: The Science of Praxis	3-0-0	3
HS 350	Contemporary Dance	3-0-0	3
HS 420	Human Resource Management	3-0-0	3
HS 431	Special Course in Sociology	3-0-0	3
HS 531	Social Institutions and Development	3-1-0	4
HS 532	Planning and Policy: Issues in India	3-1-0	4
HS 533	Development: Social, Anthropological and Political Perspectives	3-1-0	4
HS 534	Natural Resource Management and Sustainable Development	3-1-0	4
HS 535	Gender and Development	3-1-0	4
HS 536	Trends and Issues in Tribal Studies	3-1-0	4
HS 537	Development Issues in Orissa	3-1-0	4
HS 538	Urban Governance and Development	3-1-0	4

Sub Discipline: Economics

HS 340	Special Course in Economics	3-0-0	3

HS 341	Managerial Economics	3-0-0	3
HS 440	Financial Markets and Institutions	3-0-0	3
HS 441	Special Course in Economics	3-0-0	3
HS 448	Health Economics and Policy	3-0-0	3
HS 541	Economics of Development	3-1-0	4
HS 542	Poverty, Inequality and Human Development	3-1-0	4
HS 543	Global Issues in Development	3-1-0	4
HS 544	Environment and Development	3-1-0	4
HS 545	Indian Financial System	3-1-0	4
HS 546	Population Dynamics and Development	3-1-0	4
HS 548	Demographic Transition and Health Policies in Developing World	3-1-0	4
HS 549	Public Economics	3-1-0	4
HS 550	Theory of Money, Output and Employment	3-1-0	4

Sub Discipline: Laboratory Courses

CS 171	Computing Laboratory – I	0-0-3	2
HS 570	Advanced Language Laboratory	0-0-6	4
HS 572	Statistical Laboratory	0-0-3	2

Sub Discipline: Project, Seminar and Special Courses

HS 591	Research Project – I	0-0-6	4
HS 592	Research Project – II	0-0-9	6
HS 593	Seminar & Technical Writing – I	0-0-3	2
HS 594	Seminar & Technical Writing – II	0-0-3	2
HS 595	Short Term Industrial/Research Experience	0-0-3	2
HS 596	Comprehensive Viva –Voce	0-0-3	2

SCHOOL OF MANAGEMENT

Curriculum of MBA (Masters of Business Administration)

FIRST SEMESTER

Sl. No	Sub Code.	Subjects	L-T-P	Credits
1.	SM 501	Organizational I and Structure	3-0-0	3
2.	SM 503	Managerial Economics	3-0-0	3
3.	SM 505	Financial and Cost Accounting	3-0-0	3
4.	SM 507	Marketing Management	3-0-0	3
5.	SM 509	Research Methodology	3-0-0	3
6.	SM 511	Management Information System	3-0-0	3
TOTAL				**18**

SECOND SEMESTER

Sl. No.	Sub Code.	Subjects	L-T-P	Credits
1.	SM 502	Human Resource Management	3-0-0	3
2.	SM 504	Production & Operations Management	3-0-0	3
3.	SM 506	Financial Management	3-0-0	3
4.	SM 508	Quantitative Techniques and Operations Research	3-0-0	3
5.	SM 510	Economic and Legal Environment	3-0-0	3
6.	SM 512	Technology and Innovation Management	3-0-0	3
TOTAL				**18**

THIRD SEMESTER

Sl. No.	Sub Code.	Subjects	L-T-P	Credits
1.	SM 601	Strategic Management	3-0-0	3
2.		Professional Elective – I	3-0-0	3
3.		Professional Elective – II	3-0-0	3
4.		Professional Elective – III	3-0-0	3
5.		Professional Elective – IV	3-0-0	3
6.		Professional Elective – V	3-0-0	3
7.	SM 603	Internship	3-0-0	3
TOTAL				**21**

FOURTH SEMESTER

Sl. No.	Sub Code.	Subjects	L-T-P	Credits
1.	SM 602	Business Ethics & Corporate Governance	3-0-0	3
2.		Professional Elective – I	3-0-0	3
3.		Professional Elective – II	3-0-0	3
4.		Professional Elective – III	3-0-0	3
5.		Professional Elective – IV	3-0-0	3
6.		Professional Elective – V	3-0-0	3
7.	SM 604	Presentation & Comprehensive Viva Voce	0-0-0	3
TOTAL				**21**

LIST OF PROFESSIONAL ELECTIVES

Sl. No.	Sub Code.	Subjects	L-T-P	Credits
1.	SM 613	Consumer I and Marketing Research	3-0-0	3
2.	SM 614	Customer Relationship Management	3-0-0	3
3.	SM 615	Product and Brand Management	3-0-0	3

4.	SM 616	Retail Management	3-0-0	3
5.	SM 617	Sales and Distribution Management	3-0-0	3
6.	SM 618	Industrial and Services Marketing	3-0-0	3
7.	SM 619	Integrated Marketing Communication	3-0-0	3
8.	SM 620	International Marketing	3-0-0	3
9.	SM 621	Financial Institutions, Instruments and Markets	3-0-0	3
10.	SM 622	Financial Options, Futures and Swap	3-0-0	3
11.	SM 623	Commercial Banking	3-0-0	3
12.	SM 624	International finance	3-0-0	3
13.	SM 625	Financial Services	3-0-0	3
14.	SM 626	Mergers and Acquisitions	3-0-0	3
15.	SM 627	Security Analysis and Portfolio Management	3-0-0	3
16.	SM 628	Insurance and Risk Management	3-0-0	3
17.	SM 630	Project Planning and Appraisal	3-0-0	3
18.	SM 612	Customer Relationship Management	3-0-0	3
19.	SM 631	Employee Relations and Labour Legislations	3-0-0	3
20.	SM 632	Performance Management	3-0-0	3
21.	SM 633	Human Resource Planning	3-0-0	3
22.	SM 634	Organization Change and Development	3-0-0	3
23.	SM 635	Training and Development	3-0-0	3
24.	SM 636	Leadership for Corporate Excellence	3-0-0	3
25.	SM 637	Employee Compensation and Benefits Management	3-0-0	3
26.	SM 638	Strategic Human Resource Management	3-0-0	3
27.	SM 640	Knowledge Management	3-0-0	3
28.	SM 641	Materials Management	3-0-0	3
29.	SM 642	Reliability and Risk Management	3-0-0	**3**
30.	SM 643	Total Quality Management	3-0-0	3
31.	SM 644	Supply Network Management	3-0-0	3
32.	SM 645	Business Process Transformation	3-0-0	3
33.	SM 646	Operations Strategy	3-0-0	3
34.	SM 647	Project Planning, Scheduling and Monitoring	3-0-0	3
35.	SM 648	Decision Modeling and Simulation	3-0-0	3
36.	SM 651	Strategic Information System	3-0-0	3
37.	SM 652	Database Management System	3-0-0	3
38.	SM 653	E-Commerce	3-0-0	3
39.	SM 654	Software Project and Quality Management	3-0-0	3
40.	SM 655	Enterprise Resource Planning	3-0-0	3
41.	SM 656	IT Strategy	3-0-0	3
42.	SM 657	System Analysis and Design	3-0-0	3
43.	SM 658	Software Engineering	3-0-0	3

LIST OF LABORATORY COURSES

Sl. No	Sub Code.	Subjects	L-T-P	Credits
1.	SM 513	Basic Computer Lab	0-0-3	2
2.	SM 514	Statistics Lab	0-0-3	2
3.	SM 515	OB Lab	0-0-3	2
4.	SM 516	HR Lab	0-0-3	2

5.	SM 517	Business Simulation Lab	0-0-3	2
6.	SM 518	Management Games Lab	0-0-3	2
7.	SM 519	Seminar & Technical Writing – I	0-0-3	2
8.	SM 520	Seminar & Technical Writing – II	0-0-3	2
9.	SM 605	OR Lab	0-0-3	2
10.	SM 606	Banking Operations Lab	0-0-3	2
11.	SM 607	Leadership Lab	0-0-3	2
12.	SM 608	Project Lab	0-0-3	2
13.	SM 609	Language Lab	0-0-3	2
14.	SM 610	Marketing Lab	0-0-3	2
15.	SM 611	Seminar & Technical Writing – III	0-0-3	2
16.	SM 612	Seminar & Technical Writing – IV	0-0-3	2

SUMMARY OF COURSES

Sub Discipline: Marketing

SM 613	Consumer I and Marketing Research	3-0-0	3
SM 614	Customer Relationship Management	3-0-0	3
SM 615	Product and Brand Management	3-0-0	3
SM 616	Retail Management	3-0-0	3
SM 617	Sales and Distribution Management	3-0-0	3
SM 618	Industrial and Services Marketing	3-0-0	3
SM 619	Integrated Marketing Communication	3-0-0	3
SM 620	International Marketing	3-0-0	3
SM 653	E – Commerce	3-0-0	3

Sub Discipline: Finance

SM 621	Financial Institutions, Instruments and Markets	3-0-0	3
SM 622	Financial Options, Futures and Swap	3-0-0	3
SM 623	Commercial Banking	3-0-0	3
SM 624	International finance	3-0-0	3
SM 625	Financial Services	3-0-0	3
SM 626	Mergers and Acquisitions	3-0-0	3
SM 627	Security Analysis and Portfolio Management	3-0-0	3
SM 628	Insurance and Risk Management	3-0-0	3
SM 630	Project Planning and Appraisal	3-0-0	3

Sub Discipline: Human Resource

SM 631	Employee Relations and Labour Legislations	3-0-0	3
SM 632	Performance Management	3-0-0	3
SM 633	Human Resource Planning	3-0-0	3
SM 634	Organization Change and Development	3-0-0	3
SM 635	Training and Development	3-0-0	3
SM 636	Leadership for Corporate Excellence	3-0-0	3
SM 637	Employee Compensation and Benefits Management	3-0-0	3
SM 638	Strategic Human Resource Management	3-0-0	3
SM 640	Knowledge Management	3-0-0	3

Sub Discipline: Operations

SM 641	Materials Management	3-0-0	3

SM 642	Reliability and Risk Management	3-0-0	3
SM 643	Total Quality Management	3-0-0	3
SM 644	Supply Network Management	3-0-0	3
SM 645	Business Process Transformation	3-0-0	3
SM 646	Operations Strategy	3-0-0	3
SM 647	Project Planning, Scheduling and Monitoring	3-0-0	3
SM 648	Decision Modeling and Simulation	3-0-0	3

Sub Discipline: Systems & IT

SM 612	Customer Relationship Management	3-0-0	3
SM 640	Knowledge Management	3-0-0	3
SM 651	Strategic Information System	3-0-0	3
SM 652	Database Management System	3-0-0	3
SM 653	E- Commerce	3-0-0	3
SM 654	Software Project and Quality Management	3-0-0	3
SM 655	Enterprise Resource Planning	3-0-0	3
SM 656	IT Strategy	3-0-0	3
SM 657	System Analysis and Design	3-0-0	3
SM 658	Software Engineering	3-0-0	3

Sub Discipline: Project, Seminar and Special Courses

SM 519	Seminar & Technical Writing – I	0-0-3	2
SM 520	Seminar & Technical Writing – II	0-0-3	2
SM 603	Internship	0-0-0	3
SM 604	Presentation and Comprehensive Viva-voce	0-0-0	3
SM 611	Seminar & Technical Writing – III	0-0-3	2
SM 612	Seminar & Technical Writing – IV	0-0-3	2

Sub Discipline: Laboratory Courses

SM 513	Basic Computer Lab	0-0-3	2
SM 514	Statistics Lab	0-0-3	2
SM 515	OB Lab	0-0-3	2
SM 516	HR Lab	0-0-3	2
SM 517	Business Simulation Lab	0-0-3	2
SM 518	Management Games Lab	0-0-3	2
SM 605	OR Lab	0-0-3	2
SM 606	Banking Operations Lab	0-0-3	2
SM 607	Leadership Lab	0-0-3	2
SM 608	Project Lab	0-0-3	2
SM 609	Language Lab	0-0-3	2
SM 610	Marketing Lab	0-0-3	2

Detailed Syllabi of M.Sc, Integrated M.Sc., M.A., M.B.A. Programmes

DEPARTMENT OF CHEMISTRY

DETAILED SYLLABI OF COURSES

Sub. Code	Subject	L-T-P	Credits
CY 101	Chemistry	3-1-0	4
CY 170	Chemistry Laboratory	0-0-3	2
CY 211	Name Reactions & Rearrangements	3-0-0	3
CY 232	Chemical Kinetics	3-0-0	3
CY 234	Basic Physical Chemistry – II	3-1-0	4
CY 311	Concerted Reactions	3-0-0	3
CY 312	Basic Organic Chemistry – II	3-1-0	4
CY 313	Natural Products	3-1-0	4
CY 322	Basic Inorganic Chemistry – I	3-1-0	4
CY 323	Basic Inorganic Chemistry – II	3-1-0	4
CY 413	Spectroscopic Methods of Analysis	3-0-0	3
CY 431	Chemistry of Nanomaterials	3-0-0	3
CY 432	Introduction to Nanobiotechnology	3-0-0	3
CY 511	Stereochemistry and Reaction Mechanism	3-1-0	4
CY 512	Structure and Functions of Biomolecules	3-1-0	4
CY 514	Environmental Chemistry	3-1-0	4
CY 515	Spectroscopic Methods of Analysis	3-0-0	3
CY 516	Industrial Organic Chemistry	3-0-0	3
CY 517	Chemistry of Natural Products	3-0-0	3
CY 518	Polymer Chemistry	3-0-0	3
CY 519	Pericyclic Reactions and Photochemistry	3-0-0	3
CY 521	Principles of Inorganic Chemistry	3-1-0	4
CY 522	Chemistry of Transition & Non-transition Elements.	3-1-0	4
CY 523	Industrial Inorganic Chemistry	3-0-0	3
CY 524	Group Theory and Molecular Orbitals	3-0-0	3
CY 525	Advanced Co-ordination Chemistry	3-0-0	3
CY 526	Bio-inorganic Chemistry	3-0-0	3
CY 527	Supramolecular Chemistry	3-0-0	3
CY 531	Thermodynamics & Chemical Equilibria	3-1-0	4
CY 532	Chemical Kinetics & Photochemistry	3-1-0	4
CY 533	Quantum Chemistry	3-1-0	4
CY 534	Principles of Heterogeneous Catalysis	3-0-0	3
CY 535	Electrochemistry	3-0-0	3
CY 536	Colloids and Surface Chemistry	3-0-0	3
CY 537	Advanced Solid State Chemistry	3-0-0	3
CY 538	Molecular Spectroscopy	3-0-0	3
CY 539	Biophysical Chemistry	3-0-0	3
CY 541	Chemistry of Heterocyclic Compounds	3-0-0	3
CY 542	Methods on Organic Synthesis	3-0-0	3
CY 543	Molecular Rearrangement	3-0-0	3
CY 544	Instrumental Methods of Analysis	3-0-0	3
CY 558	Organometallic Chemistry	3-0-0	3
CY 571	Organic Chemistry Laboratory	0-0-9	6
CY 572	Inorganic Chemistry Laboratory	0-0-9	6
CY 573	Physical Chemistry Laboratory	0-0-9	6
CY 574	Environmental Chemistry Laboratory	0-0-9	6
CY 581	Research Project – I	0-0-6	4

CY 582	Research Project – II	0-0-6	4
CY 583	Research Project – III	0-0-9	6
CY 584	Research Project – IV	0-0-9	6
CY 591	Research Project – I	0-0-6	4
CY 592	Research Project – II	0-0-9	6
CY 593	Seminar & Technical Writing – I	0-0-3	2
CY 594	Seminar & Technical Writing – II	0-0-3	2
CY 595	Short Term Industrial / Research Experience(SIRE)	0-0-0	2
CY 596	Comprehensive Viva-voce	0-0-0	2

CY 101 CHEMISTRY 4 Credits [3-1-0]

Electrochemistry : Electrochemical cells, galvanic cells, general equation for emf of cells, Electrode potentials and its relevance to oxidation and reduction, measurement of EMF, determination of pH, dry cells, fuel cells and storage battery ; Metallic Corrosion : Types of corrosion, mechanism of corrosion, Galvanic corrosion, principle of corrosion control; Introduction to Polymer Chemistry : Introductory concepts, definition, common system chemistry and classification of polymers, resins, rubber, plastics. Characterization: molecular weight studies and molecular weight distribution. Mechanistic aspects: addition, ionic, condensation polymerization, polymerization techniques; Atomic Structure – Wave-particle duality and principle of Indeterminacy, Schrodinger wave equation, atomic orbitals, degeneracy, radial and angular dependence of hydrogen orbitals and probability distribution,Spectroscopy and Instrumentation :Introduction, basic principles and instrumentations of rotational, vibrational, electronic spectroscopy. Chemical Kinetics- First and Second order reactions, Determination of rate-reaction. Consecutive, concurrent and chain reactions. Influence of rate constant. Theory of reaction rate. Principles of Organic chemistry: Inductive effects, resonance, 63mmune63r63 and heterolytic fission of covalent bonds, reaction intermediates, addition, elimination and substitution reactions. Principles of catalysts and catalysis, industrial and biocatalysis.

Essential Reading:

1. P. W. Atkins, *Elements of Physical Chemistry*, 4th Ed., Oxford University Press, 2007.
2. J. Singh, L.D.S. Yadav, *Advanced Organic Chemistry*, Pragati Prakashan, 2009.
3. C. N. Banwell and E. M. McCash*, Molecular spectroscopy,* Tata McGraw-Hill, 7th reprint, 1999.

Supplementary Reading:

1. G. N. Mukherjee and A. Das*, Elements of Bioinorganic Chemistry,* U. N. Dhar and Sons Pvt. Ltd., Kolkata, Revised Second Edition, 2002.
2. J. E. Huheey, E. A. Keiter and R. L. Keiter, *Inorganic Chemistry, Principles of structure and reactivity,* Harper Collins, 1993.
3. Clayden, Greeves, Warren and Wothers*, Organic Chemistry,* Oxford, 2001.
4. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of physical Chemistry,* Shoban Lal Nagin Chand & Co., 2001.

CY 170 CHEMISTRY LABORATORY 2 Credits [0-0-3]

LIST OF EXPERIMENTS

Determinations of hardness of water ; Determinations of percentage purity of lime stone sample ; Determinations of 63mmune63r63 oxygen in water ; Determinations of sodium carbonate & sodium bicarbonate content in a mixture ; Determinations of sodium carbonate & sodium hydroxide content in a mixture ; Determinations of iron content in a sample ; Determinations of chloride content of water ; Determinations of proximate analysis of coal ; Determinations of carbon residue of an oil by conradson's apparatus ; Determinations of flash point of an oil by pensky-marteins closed cup flash point apparatus ; Determinations of viscosity of an oil by redwood viscometer ; Determination of

Dissociation constant of weak acids by conductometric Titration ; Determination of pH of an electrolyte by potentiometric Titration.

Essential Reading:

Material supplied in the laboratory.

CY 211 NAME REACTIONS & REARRANGEMENTS 3 Credits [3-0-0]

Name reactions in organic synthesis : Demijanov, Pinacol-Pinacolone rearrangement, Favorski Rearrangement, Fries rearrangement,Wagner-Meerwein Rearrangement, Benzil-Benzilic Acid Rearrangement, Beckmann Reaction, Curtius, Schmidt, Lossen and Wolff Reaction, Cope Reaction, Chugev Reaction,Perkin, Stobb, Hofmann, Reimer-Tiemann, Reformatsky, Grignard reaction, Diels-alder reaction, Aldol Condensation, Claisen condensation, Dieckmann condensation,Claisen rearrangement, Friedel-craft reaction, Witting reaction, Meerwein-Pondroff-Verley and Birch reduction, Clemmenson reduction, Wolf-kishner reduction.

Essential Reading:

1. A. R. Parikh, H. Parikh and K. Parikh, *Name reactions in Organic Synthesis,* Foundation Books, 2006.
2. S. N. Sanyal, *Reactions*, *Rearrangements and Reagents,* Bharati Bhawan, 2000.

Supplementary Reading:

1. J. J, Li*, Name reactions in organic synthesis,* 3rd Edition, SPRINGER 2006.
2. G. Bramhachari, Organic Name Reactions, Narosa Publishers, 2009.

CY 214 BASIC ORGANIC CHEMISTRY – I 3 Credits [3-0-0]

Aliphatic Hydrocarbons: alkanes, alkenes addition reaction, Markownikov's rule, peroxide effect, hydroboration, allylic substitution by NBS, polymerization types, free radical, cationic and anionic including the mechanism; *Alkynes*: acidity of alkynes in comparison with alkanes and alkenes, formation of acetylides, oxidation, ozonolysis and hydroboration- polymerization; Dienes: types, synthesis of 1, 3-butadiene from 1, 4-Butanediol, 1,2- and 1, 4- diol, reaction of 1, 3-butadiene, Diels-Alder reaction, synthesis rubber-buna, neoprene and natural rubber; *Cycloalkanes*: reactions, hydrogenation and halogenations, comparison of the stabilities of cycloalkanes-Beaver's-strain theory-postulates and limitations, Sasche-Mohr's theory of strainless rings, chair and boat conformations of cyclohexane; *Aromatic hydrocarbons*: aromaticity, resonance energy, resonance structures of naphthalene, anthracene and phenanthracene, electrophyllic substitution reactions of benzene with mechanism, ortho-para orienting groups; *Alchohols*: synthesis and reactions, *phenols*: synthesis, reactions (Reimer-Tiemann's reaction. Kolbe's reaction and Frie's rearrangement), synthesis of resorcinol and napthols (α- and β-); Carbonyl compounds: nomenclature, addition reaction, Aadol condensation, Knoevenagel condensation, Perkin's reaction, Cannizzarro's reaction, Claisen condensation, Wolf- kishner, MPV, base catalyzed halogenations reaction of ketones (mechanism for all the reactions). Alpha, beta unsaturated carbonyl compounds- preparation and properties, mechanism of Michael addition; Carboxylic acids, Hydroxyl acids: classification, synthesis and synthetic applications; *Aromatic nitro compounds*: reduction in neutral, acidic and alkaline media, TNT, distinction between nitroalkanes; Amines: classification, separation of amines from mixture by Hinsberg's method using toluene sulphonyl chloride, basicity of amines. Reaction with nitrous acid, Hoffmann-Martius rearrangement; Diazonium Compounds: preparation and application in organic transformations.

Essential Reading:

1. P.Y. Bruice, Organic Chemistry, 3rd Edition, Pearson Education, 2009.
2. R.K. Bansal, Organic Chemistry, Norosa Publication, 2001.

Supplementary Reading:

1. S.K. Ghosh, Advanced general organic Chemistry, Part I & II, New Central Book Agency, Pvt. Ltd. 2009.

CY 221 CHEMISTRY OF INDUSTRIAL MATERIAL 4 Credits [3-1-0]

Fuel and combustion: Introduction, classification, calorific value, Petroleum and coal based chemicals: Composition of petroleum, cracking processes, knocking, diesel engine fuels, distillation of coal water gas, CNG, LPG, Biodiesels. *Polymers:* polymerization mechanisms, Addition, condensation, step growth, chain growth, method of polymerization. *Oils and fats:* Solvent extraction of oils, hydrogenation of oil, use of oil in the manufacturing of soap, Surface active agents: classification and manufacturing of detergents used for cleansing purpose. Dyes and pigments: Types of dyes, paints and varnishes. Chemistry of cement, metal extraction, Pesticides : DDT manufacture, BHC manufacture, parathion manufacture.

Essential readings:

1. Outlines of Chemical Technology. By M. Gopala Rao and Marshall Sittig, Affiliated East-West Press Pvt. Ltd.

Supplementary readings:

1. P. J. Chenier, *Survey of Industrial Chemistry*, 3rd Ed. Springer, 2002
2. C. A. Clausen and G. Mattson, *Principles of Industrial Chemistry*, Wiley-Interscience, 1978.

CY 231 BASIC PHYSICAL CHEMISTRY – I 4 Credits [3-1-0]

Macroscopic properties of matter: The properties of gases, kinetic model of gases, Real Gases, Thermodynamics, 1st Law, conservation of energy, internal energy and enthalpy, Thermochemistry: Physical and chemical change, 2nd law; Entropy, Gibb,s energy, phase equilibrium, Pure substances: Thermodynamics of transitions, Phase diagrams, Properties of mixtures: Thermodynamic descriptions, Colligative properties, Phase diagram of mixtures, Principles of Chemical equilibrium: Thermodynamic background, Response of equillibria to the conditions, Consequence of equilibrium: Proton transfer reactions, salts in water, solubility equillibria, Electrochemistry: Ions in solutions, electrochemical cells, applications of standard potentials, Chemical Kinetics: Rates of reactions, Temp dependence of reaction rates, reaction mechanisms, reactions in solutions, catalysis and chain reactions

Essential readings:

1. P.W. Atkins and Julio de Paula, Elements of Physical Chemistry, Oxofrd University Press, 1992

Supplementary readings:

1. G N Barrow, *Physical Chemistry,* TATA MCGRAW-HILL, 2007.
2. K. L. Kapoor*, Text Book of Physical Chemistry,* MACMILLAN, 2006

CY 232 CHEMICAL KINETICS 3 Credits [3-0-0]

Chemical Kinetics : Methods of determining rate laws.Mechanisms of photochemical, chain and oscillatory reactions.Collision theory of reaction rates; steric factor, treatment of unimolecular reactions.Theory of absolute reaction rates, comparison of results with Eyring and Arrhenius equations, ionic reactions; salt effect.Homogeneous catalysis and Michaelis – Menten kinetics; heterogeneous catalysis. **Kinetics in the excited electronic states** : Laws of light absorption, Photoelectric effect, photo chemical equivalence, fluorescence, Phosphorescence, Chemiluminiscence, Photosensitization, pre-dissociation and quantum efficiency of photochemical reaction, photodissociation. Isomerisation and cycloaddition, Flash phtolysis, Chemistry of vision.

Essential Reading:

1. M. R. Wright*, An Introduction to Chemical Kinetics,* John Wiley & Sons, 2005.
2. J. Raja Ram, and J. C. Kuriacose,*Kinetics and Mechanism of Chemical Transformations,* MacMillan Indian Ltd., New Delhi, 1993.

Supplementary Reading:

1. R. I. Masel, *Chemical Kinetics & Catalysis, Wiley-Interscience;* 1st Edition, 2001.
2. K. K. Rohatgi, S. Mukherjee, *Fundamentals of Photochemistry,* Wiley, New York, 3rd Edition, 1978.

CY 271 UG ORGANIC CHEMISTRY LABORATORY 2 Credits [0-0-3]

Detection of functional groups: Element detection, detection of amine, alcohol, nitro, acid, amide etc., Distilation, chromatography, Purification of organic solvents, drying of organic solvents. Preparation of picric acid, Benzoin. Extraction of caffine from tea leaf, cassine from milk, isolation of club oil.

Essential Reading

1. V K Ahluwalia and R Aggarwal, *Comprehensive practical organic chemistry*, University press. 2000
2. Brian S. Furniss, *Vogel's Text Book of Practical Organic Chemistry*, ELBS Longman, 5th edition, 1996.

Supplementary Reading

1. D S Gupta , *Experimental Organic Chemistry, Qualitative and Quantitative*, TATA MCGRAW HILL 2004 *,*
2. Addison Ault, *Techniques and Experiments for Organic Chemistry*, University Science Book.1998

CY 273 UG PHYSICAL CHEMISTRY LABORATORY 2 Credits [0-0-3]

1. Study of the distribution equilibrium of iodine in water/tolune
2. Determination of hydrolysis rate of ester
3. Determination of molecular mass by Victor Mayer apparatus
4. Estimation of Ca and Mg in mixture by EDTA
5. Determination of Eutectic point of a binary mixture
6. Estimation of Ni by DMG complex by spectrometry
7. Ionization constant of a week acid
8. Solubility of a sparingly soluble salt

Essential Reading

1. R.C. Das and B. Behera *, Experimental Physical Chemistry, ,* Tata McGraw Hill 2000

Supplementary Reading

1. D. Alart, *Practical Physical Chemistry*, Longman, 1993.

CY 311 CONCERTED REACTIONS 3 Credits [3-0-0]

Molecular orbitals and symmetry operations; Pericyclic reactions, Froniter orbital approach, Aromatic transition state approach (Huckel and Mobius systems) Woodward Hofmann rule for pericyclic reactions); Electrocyclic Reactions, correleation diagram; Cycloaddition reaction, [4+2]-cycloaddition reaction (Diels-Alder reaction), regioselectivity of Diels-Alder reaction, [2+2]-

cycloaddition reaction; 1,3 dipolar cycloaddition reaction; Sigmatropic reactions :Orbital description, [1,5], [2,3], [3,3] sigmatropic rearrangement, Claisen rearrangement, Cope rearrangement.

Essential Reading:

1. J. Singh & J. Singh, Photochemistry & Pericyclic Reactions, New Age International (P) Ltd., 2007.
2. I. Fleming, *Frontier Orbitals and Organic Chemical Reactions,* Wiley, 1976.

Supplementary Reading:

1. B. B. Woodward and Hoffman*, Conservation of Orbital Symmetry,* Verlag Chemie Academic Press, 1971.
2. M. Smith, *Organic Synthesis,* Mc Graw Hill, 2nd Ed. 2004.

CY 312 BASIC ORGANIC CHEMISTRY – II 4 Credits [3-1-0]

Active methylene compounds: Preparation and synthetic applications of malonic ester and ethyl acetoacetate, Keto-enol tautomerism in ethyl aceto acetate.

Stereochemistry: Elements of symmetry, asymmetry and dissymmetry, Chiiral carbon atom, cause of optical activity, enantiomers, diastereomers, Optical isomerism in tartaric acid and biphenyls, Racemisation, resolution, methods of resolution Walden inversion, Asymmetric synthesis.

Geometrical isomerism: Designation of cis-trans and E-Z notations, Geometrical isomerism of oximes, Backmann rearrangement.

Organometallic compounds: Definition with examples, Preparation and synthetic applications Grignard reagent, organolithium compounds, Organozinc compounds, organo copper compounds, selected Name reactions and their application in organic synthesis.

Oils and fats: Analysis of oils and fats-determination of acid value saponification value, iodine value and their importance, merits and demerits of syndets in relation to soaps, Cleansing action of soaps.

Waxes: Animal and plant waxes (one example each)

Natural pigments: Structural formulae and their importance of anthocyanin, β-carotene, haemoglobin.

Dyes: Colour and constitution, chromophore-auxochrome theory, Classification of dyes based on applications with examples, Synthesis of malachite green and indigo, Structural elucidation of alizarin and its synthesis.

Heterocyclic compounds: Classification, synthesis of furan, thiophene, pyrrole, pyridine, indole, 67mmune67r67, isoquinoline, pyrimidine (one method each), Aromaticity and basicity of pyrrole and pyridine.

Uric acid: Elucidation of structure and synthesis by Fischer's by Fischer's method, conversion of uric acid to purine and caffeine, Synthesis of guanine and theobromine.

Essential readings:

1. P.Y. Bruice, Organic Chemistry, Pearson Education, 3rd Ed. 2009.
2. T. W. G. Solomons & C. B. Fryhle, Organic Chemistry, Wiley student Edition, 8th Ed. 2004.

Supplementary readings:

1. T. L. Gilchrist, *Heterocyclic Chemistry*, Pearson Education, 3rd Ed. 2007.
2. S. K. Ghosh, Advanced General organic Chemistry, Part I &II, New Central Book Agency, Pvt. Ltd. 2009.

CY 313 NATURAL PRODUCTS 4 Credits [3-1-0]

Alkaloids: Introduction, Occurrence, Functions of Alkaloids, Classification, Isolation, Properties, Determination of molecular structure, Detailed discussions on Coniine *(Hemlock alkaloid)*, Nicotine, piperine, Atropine.

Terpenoids: Introduction, Occurrence, Isolation, Classification, Structural features of Terpenoids, Determination of molecular structure, specific importance to reactions of double bonds with Chromic acid, Ozone, catalytic hydrogenation, Tilden reagent, Hydroxylating agents etc. Monoterpenoids, diterpenoids, Triterpenoids. Detailed discussions on Myrcene, Citral, Menthol, Bisabolone. Geometrical considerations of Neral & Geranial, Menthol.

Carbohydrates : Introduction, Nomenclature, Reactions of Monosaccharides, Interconversions, Ring structure of Aldoses and ketoses. Projection formula for Monosaccharides. Conformation of Monosaccharides.

Hormones: Definition, classification, synthesis of adrenaline, thyroxine, Structural formulae of estradiol, progesterone and testosterone and their importance. Peptide hormones-oxytocin and insulin – action, uses and side effects.

Insecticides: Fungicides and Herbicides: Classification, synthetic organic insecticides and fungicides and their importance; BHC, Lindane, Malathion, Herbicides: Diuren, 2, 4-D[2,4-dichlorophenoxy acetic acid] and their importance.
Wood protectants: Creosote oil, pental chloraphenols.

Essential readings:

1. S. V. Bhat, B.A. Nagaramgagi, M. Srikumar, *Chemistry of Natural Products*, Alpha Science International Ltd, 2005.
2. O. P. Agarwal, *Chemistry of Natural Products*, Vol- 1 &Vol-2, Goel publishing House, 1989.

Supplementary Reading

1. K. C. Nicolaou, T. Montagnon, *Molecules that changed world*, Wiley-VCH, 1st ed., 2008.
2. James R Hanson, *Natural Products: the secondary metabolites*, Royal society of Chemistry, 2003.

CY 322 BASIC INORGANIC CHEMISTRY – I 4 Credits [3-1-0]

Atomic structure: de-Broglie matter waves, Uncertainty principle, Schrodinger wave equation, hydrogen atom, quantum numbers and its significance, Radial and angular wave functions, spherical harmonics, Radial and angular distribution curves, shape of s, p, d orbitals, LS coupling.
Chemical bonding: Ionic bond: Born equation, polarizability, Fajan's rule, percentage ionic character and solvation energy, covalent bonds, VBT, Resonance, directional characteristics, hybridization and deduction of geometry, Qualitative treatment of MO theory.
p-Block elements: Boron, Carbon, Nitrogen, Oxygen and Halogen family
d-Block elements: electronic configuration and comparative study of ionic radii, ionization potential, redox potential, oxidation state, metallic nature.
Coordination chemistry: Ligands, coordination numbers, coordination sphere, Nomenclature, Werner's theory, EAN, Chelates, isomerism in coordination compounds, Valence Bond theory, octahedral, tetrahedral and square planner complexes

Essential readings:

1. J.D. Lee, Concise Inorganic Chemistry, 5th edition, Blackwell Publishing, 2008

Supplementary readings:

3. Huheey, Keiter and Keiter, Inorganic chemistry Principle, structure and reactivity. 4th edition.

CY 323 BASIC INORGANIC CHEMISTRY – II 4 Credits [3-1-0]

Crystal field Theory, qualitative idea about d-orbital splitting in octahedral and square planner complexes, Calculation of CFSE, explanation of magnetism, geometry and colour of coordination compounds, John-Teller distortion. Thermodynamic, kinetics and magnetic aspects of metal

complexes. Chemistry of f-block elements, Lanthanides and actinides, Organometallic chemistry: definition, nomenclature and classification, preparation and properties, Bonding and application alkyl and aryl and carbonyl complexes, Inorganic polymers: Types of inorganic polymers, comparison with organic polymers, structure aspects and application of silicones, phosphonitrilic halides and condensed phosphates.

Essential readings:

2. J.D. Lee, Concise Inorganic Chemistry, 5th edition, Blackwell Publishing, 2008

Supplementary readings:

3. Huheey, Keiter and Keiter, Inorganic chemistry Principle, structure and reactivity. 4th edition.

CY 374 UG INORGANIC CHEMISTRY LABORATORY 2 Credits [0-0-3]

Quantative analysis of mixture of inorganic substances containing six radicals (interfering acid radicals like phosphate, fluoride and mixture of acid radicals like carbonate, sulfite, sulfide, nitrate, chloride, bromide, phosphate, arsenate, nitrate, iodate and sulfate)

Essential Reading

1. G. Svehla, *Vogel's qualitative inorganic analysis*, Harlow Longman, 2002.
2. A I Vogel, John Bassett, *Vogel's textbook of quantitative inorganic analysis: including elementary instrumental analysi*, Longman,2003

Supplementary Reading

1. A I Vogel , *Qualitative Inorganic Analysis*, Orient Longman – 1979.

CY 375 INSTRUMENTATION LABORATORY 2 Credits [0-0-3]

Simple experiments will be conducted to elucidate the working principles, instrumentation and handling of Gas Chromatograph, UV-Vis spectrometer, IR spectrometer, Polarimeter, conductivity meter, pH meter and Nephlometer

Essential Reading

1. R.C. Das and B. Behera *, Experimental Physical Chemistry, ,* Tata McGraw Hill 2000

Supplementary Reading

1. D. Alart, *Practical Physical Chemistry*, Longman, 1993.

CY 413 SPECTROSCOPIC METHODS OF ANALYSIS 3 Credits [3-0-0]

General introduction to electromagnetic spectrum and molecular spectrospocpy, spectroscopy, spectrometry, and spectrum, Nature of electromagnetic radiation and spectrum, Absorption of electromagnetic radiation by organic molecule. Types of molecular energy and molecular spectroscopy. Infrared Spectroscopy: Basic theory, instrumentation and application to functional group determination,;UV-Visible Spectroscopy :Basic concepts, instrumentation and applications;Mass Spectrometry, Principle, Instrumentation and applications; NMR Spectroscopy: Basic principles, Chemical shift, Spin-Spin Coupling, Coupling Constant, NOE, ^{13}C NMR, heteronuclear coupling, Elementary ideas on 2D NMR spectroscopy; Problem involving these techniques for structural determination and other applications.

Essential Reading :

1. D. C. Pavia, G. M. Lampman, G. S. Kriz , *Introduction to Spectroscopy, 3rd Edition,* THOMSON, 2007.
2. J. Mohan, *Organic Spectroscopy,* Narosa Publishing House, 2004

Supplementary Reading:

1. B. H. Williams, I. Flemming*, Spectroscopy Methods in Organic Chemistry,* McGraw Hill,2005.
2. Bessler and Silverstein*, Spectroscopy of Organic Compounds,*JOHN WILEY, 2001.

CY 431 CHEMISTRY OF NANOMATERIALS 3 Credits [3-0-0]

Introduction to Nanoparticles and Nanotechnology, Methods of Preparation, top down and bottom up approach, Characterization methods, Properties and size effect of nanomaterials, electrical, Mechanical, Magnetic, Optical and catalytic properties, Applications of nanotechnology in industry.

Essential Reading:

1. G. Ozoin*, Nanochemistry: A Chemical approach to nanomaterials,* Springer-Verlag, 2005.
2. C. N. R Rao, A. Muller, A. K Cheetham, *Nanomaterials Chemistry,* Wiley-VCH, 2007.

Supplementary Reading:

1. M. Hosokawa, K. Nogi, M. Naito, Y. Yokoyama, *Nanoparticles Technology Handbook,* Elsevier, 2007.

CY 432 INTRODUCTION TO NANOBIOTECHNOLOGY 3 Credits [3-0-0]

Introduction tonanomaterials, nanobiotechnology**,** nanoparticle production by microbes,DNA and Protein based nanostructures, Application of nanoparticles in Biological Detection**,** gold nanoparticle conjugates, Application of luminescent quantum dots in biological imaging**,** Emerging Nanotechnologies: nano labels, biosensors, medicines.

Essential Reading:

1. C. M. Niemeyer and C. A. Mirkin,*Nanobiotechnology: Concepts, Applications and Prospectives*, Wiley Interscience Publications, 2005.
2. M. A. Stroscio and M. Dutta, *Bioelectric Engineering Vol II, Biological nanostructures and Applications of Nanostructures in Biology: Electrical, Mechanical, and Optical Properties*, Kluwer academic publications, 2000.

Supplementary Reading:

1. C. A. Mirkin and C. M. Niemeyer *Nanobiotechnology II: More Concepts and Applications*,Wiley Intersciences Publications, 2008.

CY 511 STEREOCHEMISTRY AND REACTION MECHANISM 4 Credits [3-1-0]

Stereochemistry : Classification, 70mmune70 modification, molecules with one, two or more chiral centres; Configuration nomenclature, D L, R S and E Z nomenclature, conformations and stability of cyclohexanes (mono-, di-, and trisubstituted), cyclohexenes, cyclohexanones. Reaction intermediates, Carbocation, carbanion, Free radicals, 70mmune70 and nitrene (generation, structure, stability and reactions). Substitution Reaction: Classification, Aliphatic nucleophilic substitution reaction:S_N1, S_N2, S_Ni reactions, solvent effect, neighboring group participation reactions.Aromatic Nucleophilic substitution reactions, benzyne mechanism. Aliphatic Electrophilic substitution reactions, aromatic electrophilic substitution reaction, orientation and reactivity in substituted benzene ring ortho-para ratio. Addition to Carbon-Carbon Multiple Bonds, addition to carbon-hetero multiple bonds. Electrophilic, nucleophilic and free radical addition reactions. Elimination Reactions E1, E2 and E1 CB mechanisms. Stereospecificity, regioselectivity and stereoselectivity of elimination reactions. Relative reactivity of distereoisomers in ionic elimination, intermolecular rearrangements and neighboring group participation reactions.

Essential Reading:

1. J. March, *Advanced Organic Chemistry: Reactions Mechanism and Structure* , 4th Ed., John-Wiley and Sons,1999.
2. J. Singh & L. D. S. Yadav, Advanced Organic Chemistry, 4th Ed., Pragati Prakashan, 2009.

Supplementary Reading

1. Clayden, Greeves, Warren and Wothers*, Organic Chemistry;* Oxford, 2001.
2. J. M. Coxan*, Principles of Organic Synthesis,* 3rd Ed. Thomson Science, 1998.

CY 512 STRUCTURE AND FUNCTIONS OF BIOMOLECULES 4 Credits [3-1-0]

Carbohydrates: Ring and open chain structure of glucose and fructose. Reactions of glucose and fructose. Mutarotation. Inter conversion reactions- aldose to ketose, ketose to aldose, chain elongation and chain degradation, epimerization. Disaccharides: sucrose, Lactose, cellobiose, Reducing and non-reducing sugars, Polysaccharide: Starch, glycogen, Cellulose and Chitin, analysis of carbohydrates. Aminoacids, Proteins and nucleic acid: Proteins *(structure and functions):* Amino acids, structural features, optical activity, essential and non-essential amino acids, iso-electric point, synthesis and chemical properties of α amino acids. Peptides and it's structure determination. Polypeptides or proteins: classifications, primary, secondary, tertiary and quaternary structure of proteins, glycoproteins, denaturation and folding, enzymes.Nucleic acids*:* Nitrogeneous base and pentose sugars, Nucleosides, nucleotides,Chemical and enzymatic hydrolysis, structure and functions of nucleic acids; DNA, RNA (m-RNA, t-RNA, r-RNA), an overview of gene expression (replication, transcription and translation), genetic code (origin, Wobble hypothesis and other important features), genetic errors, Central dogma, Protein synthesis.

Essential Reading:

1. D. L. Nelson and M. M. Cox*, Lehlinger Principles of Biochemistry,* W. H. Freemanpublisher,4th Ed, 2004.
2. T. K. Lindhorst, *Essentials of Carbohydrate Chemistry and Biochemistry* (Wiley-VCH), 2nd Revised Edition, 2003.

Supplementary Reading:

1. U. Satyanarayan , *Biochemistry,* New Central Book Agency, 3rd ed.,2006.
2. L.Stryer, J. Berg, J.L. Tymoczko , Biochemistry,W.H. Freeman Publisher, 6th Ed., 2006.

CY 514 ENVIRONMENTAL CHEMISTRY 4 Credits [3-1-0]

Chemistry of Environment : Environmental segments, atmospheric structure chemistry of lower and upper atmosphere, radiation balance of earth .Major air pollutant, sources and their effect. Green house effect, acid rain, depletion of ozone layer, global worming .Air pollution abatement technology. Chemistry of water environment: Classification of water pollutants, characteristics of waste water, water quality parameters and their measurements.Waste water treatment: preliminary, primary, secondary, tertiary treatment . Waste water from some typical industries ,sources, characteristics , effect and treatment option:textiles, refinery, leather, foods, sugar, fermentation, paper and pulp ,fertilizer ,soap and detergents ,electroplating and pharmaceuticals. Solid waste disposal and management: classification and origin, methods of solid waste disposal. Microbiology involved in solid waste disposal. Soil pollution :Chemical composition of the soil, the exploitation of the mineral resources and abuse of the earth, soil pollution due to natural and artificial agencies and its effects, remedial measures to check the pollution. Energy and Environment: Energy sources, renewable and non-renewable, primary and secondary fossil fuels, their occurrence and estimation of reserves.

Essential Reading:

1. Mani Vasakam, *Physico Chemical Examination of Water, Sewage and Industrial effluents*, Pragati Prakashan, 1991.
2. A. K. Dey, *Environmental Chemistry*, Wiley Eastern, 2002.

Supplementary Reading:

1. L.T. Pryde, *Environmental Chemistry – An Introduction*, Menlopark, 1973.
2. *Environmental Chemistry: A Global Prospective,* Oxford University, 2000.

CY 515 SPECTROSCOPIC METHODS OF ANALYSIS 3 Credits [3-0-0]

General introduction to electromagnetic spectrum and molecular spectroscopy, spectroscopy, spectrometry, and spectrum, Nature of electromagnetic radiation and spectrum, Absorption of electromagnetic radiation by organic molecule. Types of molecular energy and molecular spectroscopy; Infrared Spectroscopy: Theory and instrumentation, application of IR Spectroscopy for determination of functional groups;UV-Visible Spectroscopy, Basic concepts and instrumentation. Factors affecting the position of UV bands, Characteristic absorption of Organic compounds, Application of UV spectroscopy, NMR spectroscopy. Spin active nuclei, orientation of spinning nuclear magnets, chemical shift, factor affecting the chemical shift, Spin-spin splitting theory, NOE, de-coupling experiments, CNMR, hetronuclear coupling, 2D NMR, applications of NMR spectroscopyfor structure determination; Mass Spectrometry, Principle, Instrumentation, General methods of fragmentation, interpretation and application of mass spectra. Problem involving these techniques for structural determination, Recent development in the above fields.

Essential Reading:

1. Bessler and Silverstein, *Spectroscopy of Organic Compounds*, John Wiley, 2001.
2. D. C. Pavia, G. M. Lampman, G. S. Kriz, *Introduction to Spectroscopy*, 3rd Edition, THOMSON, 2007

Supplementary Reading:

1. J. Mohan, *Organic Spectroscopy*, Narosa Publishing House, 2004.
2. B. H. Williams, I. Flemming, *Spectroscopy Methods in Organic Chemistry* , McGraw Hill, 2005.

CY 516 INDUSTRIAL ORGANIC CHEMISTRY 3 Credits [3-0-0]

Basic products of industrial syntheses, chemicals from natural gases, petrochemicals and coal; chemicals of industrial importance: olefins, diolefines, acetylens, halocompounds, alcohols, aromatics, amides, polyamides, organic reactions in industrial synthesis (oxidation, hydration, hydrogenation, dehydrogentation, hydroformylation and polymerization) fermentation technology, polymers, thermoplastics, thermosetting resins, polymerization techniques, polymer characterization, polymer degradation, paints, pigments and coating.

Essential Reading:

1. K. Weissermal, H. I. Arpe, C. R. Lindley,*Industrial Organic Chemistry*, 4th Edition,Wiley-interscience 2003.
2. A. Wittcoff, B. G. Reuben, and J. S. Plotkin, *Industrial Organic Chemistry,* 2nd Edition,Wiley – interscience, 2004.
3. F. W Billmeyer, *Text book of Polymer Science*, Johns Wiley and sons Publication, 3rd Edition, 1984

Supplementary Reading:

1. K. Weissovmel, H. J. Prpe;*Industrial Organic Chemistry*;Wiley-VCH, 2002.
2. P. J. Chenier, *Survey of Industrial Chemistry*, 3rd Edition, Springer, 2002.

CY 517 CHEMISTRY OF NATURAL PRODUCTS 3 Credits [3-0-0]

Alkaloids: Introduction, Occurrence and isolation, function of alkaloids in plant, general properties, nomenclature, and classification of alkaloids. Isolation, properties and structural elucidation of Quinine, Morphine: (structure, synthesis, molecular re-arrangement, stereo chemistry and bio-genesis). Steroids: Introduction, nomenclature of steroids, absolute configuration of steroid. Occurrence, isolation, Structure elucidation, and chemical properties of Cholesterol. Terpenoids:

Introduction, isolation, and classification of terpenoids. General properties, structure determination of Citral and Camphor. Vitamins: Introduction, chemical properties and structure elucidation of vitamin A, Vitamin B, Ascorbic Acid and Vitamin D.

Essential Reading:

1. S. V. Bhat, B. A. Nagaramgagi, M. Srikumar, *Chemistry of Natural Products*, Alpha Science International Ltd, 2005.
2. O. P. Agarwal, *Chemistry of Natural Products*, Vol- 1 &Vol-2, Goel publishing House, 1989.

Supplementary Reading:

1. K. C. Nicolaou, T. Montagnon, *Molecules that changed world*, Wiley-VCH, 1st Ed., 2008.
2. J. R. Hanson, *Natural Products: the secondary metabolites*, Royal society of Chemistry, 2003.

CY 518 POLYMER CHEMISTRY 3 Credits [3-0-0]

Introductory concepts, definition, common system chemistry and classification of polymers, synthetic and natural polymers, types of polymerization, addition, condensation, co-ordination and ring opening polymerization, Preparation, properties and uses of some important thermoplastic (i.e. PE, PVC, Teflon, PS, PMMA)and thermosetting resins (i.e. Phenolic resin, Amino resin and Epoxy resin), natural and synthetic rubbers, Fibers (i.e. Nylons, PAN, Polyurethanes). Polymer Characterization: molecular weight studies and molecular weight distribution, polydispersive index, determination of molecular weight of polymers. Polymer behavior, crystalline and thermal behavior, Glass transition temperature, factor influencing glass transition.Polymerization techniques: bulk, solution, emulsion, and suspension polymerization, polymer colloids and polymer solution. Thermodynamics aspect of Polymerization, Stereo Chemistry and mechanism of polymerization: free radical, cationic and anionic polymerization. Relevant aspects of physical properties of polymer systems, rheological properties, polymer processing, processing techniques i.e. molding, casting, extrusion and, calendaring techniques. Polymer degradation and stabilization, biological degradation of polymers.Polymers & environments, environmental pollution by polymers.

Essential Reading:

1. J. W. Nicolson, *The chemistry of polymers*, RSC publishing, 3rd Ed., 2006
2. P. Bahadur and N.V. Sastry, *Principles of Polymer Science*, Norosa Publication, 2nd Edition, 2005.

Supplementary Reading:

1. F. W Billmeyer, *Text book of Polymer Science*, Johns Wiley and sons Publication, 3rd Edition, 1984
2. I. M. Cambell, *Introduction to synthetic polymer*, Oxford university press, 2nd Ed., 2000.

CY 519 PERICYCLIC REACTIONS AND PHOTOCHEMISTRY 3 Credits [3-0-0]

Molecular orbitals and symmetry operations; Pericyclic reactions, Froniter orbital approach, Aromatic transition state approach (Huckel and Mobius systems) Woodward Hofmann rule for pericyclic reactions); Electrocyclic Reactions, correleation diagram; Cycloaddition reaction, [4+2]-cycloaddition reaction (Diels-Alder reaction), regioselectivity of Diels-Alder reaction, retroDiels-Alder reactions, heteroatom Diels-Alder reactions, Intramolecular Diels-Alder reactions [2+2]-cycloaddition reactions, 1,3 dipolar cycloaddition reactions; Sigmatropic reactions : Orbital description, [1,5], [2,3], [3,3] sigmatropic rearrangement, Claisen rearrangement, Cope rearrangement. Photochemistry: Introduction, Jablonski diagram, photochemical reactions including photochemical elimination reactions, Norrish type I process, Norrish type II process, photochemical reductions, photochemical oxidations, photochemical cyclization and photochemical isomerization and rearrangement, photosubstitution, photoaddition, Barton reaction, Paterno Buchi reaction, Nazarov cyclization,.

Essential Reading:

1. J. Singh & J.Singh, Photochemistry and Pericyclic Reactions, New Age International (P) Ltd., 2007.
2. B. B. Woodward and Hoffman, *Conservation of Orbital Symmetry*, Verlag Chemie Academic Press, 1971.
3. M. Smith, *Organic Synthesis*, Mc Graw Hill, 2nd Ed. 2004.

Supplementary Reading:

1. W. Carruthers, *Some Modern Methods of Organic Synthesis*, Cambridge University, Press, 1993.
2. I. Ninomiya and T. Naito, *Photochemistry Synthesis*, Academic Press, 1989.

CY 521 PRINCIPLES OF INORGANIC CHEMISTRY 4 Credits [3-1-0]

Modern view of atomic structure, wave mechanical description of electron and orbital. Covalent Bond: The natures of covalent bond, resonance, formal charge, overlap of atomic orbital, partial ionic character of a covalent bond, electronegativity, electron affinity, polarization. VBT/VSEPR, inert pair effect, diagonal relationships. Molecular Orbital Treatment: Hydrogen molecule ion, molecular orbital of diatomic molecules like H_2, N_2, O_2, F_2, CO and NO. Hydrogen bond & Vander wall force bond. **Acid-base theories**: Bronsted, Lewis and Lux-Flood theories, HSAB model. Theories of Metal-Ligand bonding and stereochemistry: Valency bond theory, crystal field theory, tetrahedral, octahedral complexes; Chemistry of selected Inorganic Compounds: Acyclic & cyclic ring systems, boranes, carboranes, silicones, phosphazens (structure and reactivity); Inert gases, Structure and reactions of inert gas compounds.

Essential Reading:

1. J. E. Huheey, E. A. Keiter and R. L. Keiter, *Inorganic Chemistry, Principles of structure and reactivity,* Harper Collins 1993.
2. Cotton and Wilkinson*, Advanced Inorganic Chemistry,* Wiley Eastern, 1976.

Supplementary Reading:

1. M. Chanda*, Structure and Chemical bond,* Tata McGraw Hill Atomic Edition, 2000.
2. D. F. Shriver, P. W. Atkins and C. H. Langford*, Inorganic Chemistry,* Oxford University Press, 1990.
3. N. N. Greenwood and E. A. Earnshaw, *Chemistry of Elements*, Pergaman Press, 1984.

CY 522 CHEMISTRY OF TRANSITION AND NON- TRANSITION ELEMENTS 4 Credits [3-1-0]

S and P-block elements and their reactivity; d-block Elements : Introduction, chemistry of titanium group elements, technetium and Rhenium, Metal carbonyls : Preparation, properties and bonding of iron, cobalt and nickel carbonyls, general treatment of isopoly molybodates and vanadates. Heteropoly acids. Cages & clusters of elements, structural variety, properties and implications of borides, carbides, silicides, nitrides, phosphides, oxides and sulphides of transition elements, multiple bonds and cluster variety of transition metals. Structure, synthesis and reactions of boranes, carboranes and metalloboranes. F-block Elements : Chemistry of lanthanides, position in the periodic table. Electronic configuration, oxidation states, color paramagnets, lanthanide contraction general methods of extraction. Actinides : Electronic structure, ionic radii, oxidation state, spectra and paramagnetic properties of actinides elements, Actinide hypothesis, chemistry of uranium and thorium, isolation of neptunium, plutonium and americium and their aqueous chemistry, introduction to transamoricium elements.

Essential Reading:

1. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann *,Advanced Inorganic Chemistry,* 6th Edition Wiley, Chichester, 1999.

2. D. F. Shriver, P. W. Atkins and C. H. Langford, *Inorganic Chemistry,* Oxford University press, 2002.
3. J. D. Lee, Advanced Inorganic Chemistry, Wiley Sons, 2009.

Supplementary Reading:

1. A. Kettle*, Physical Inorganic Chemistry,* Freeman, N.Y., 1996.
2. N. N. Greenwood and A. Earnshaw,*Chemistry of the Elements*, 2nd ed Butterworth- Heinman, London, 1997.
3. Cotton*, Lanthanide and Actinide Chemistry,* John Wiley & Sons, 2006.

CY 523 INDUSTRIAL INORGANIC CHEMISTRY 3 Credits [3-0-0]

Introduction to chemical industry, Industrial Gases: carbon dioxide, carbon monoxide, sulphur dioxide, hydrogen, oxygen, nitrogen, rare gases of the atmosphere, coal gas, water gas, manufacture of producer gas. Manufacture of ammonia, urea, nitric acid, calcium ammonium nitrate, cement, glasses, carbon black, abrasives, fertilizers, pulp and paper. Zeolites, Surface active agents, High purity electronic materials, explosives and propellants, extraction of iron, aluminium, copper, tin, lead from ores. Application of catalysis in industry.

Essential Reading:

1. H. L. White, *Introduction to Industrial Chemistry*, Wiley-Interscience, 1986.
2. P. J. Chenier, *Survey of Industrial Chemistry*, 3rd Ed. Springer, 2002.

Supplementary Reading:

1. A. Clausen and G. Mattson, *Principles of Industrial Chemistry*, Wiley-Interscience, 1978.

CY 524 GROUP THEORY AND MOLECULAR ORBITALS 3 Credits [3-0-0]

Groups, sub-groups, cossets, classes, symmetry elements and symmetry operations. Matrix formulation of group theory (Idea of matrix multiplication, inverse, trace, diagonalisation, eigen values and eigen vectors should be given). Classification of point groups (and octahedral group are to be discussed). Molecular orbitals : Hydrogen like orbitals, Molecular orbital calculation Electronic energy levels. The LCAO method, Overlap and Coulomb Integrals. Solution of problems dealing with bicylobutadiene, butadiene pentene and toluene. Bond order, free valance index, charge distribution, mobile bond order, self consistent field and length. Aromaticity rule, Application of group theory to simplification of M.O.determination.

Essential Reading:

1. F. A. Cotton, *Chemical Applications of Group Theory*, Wiley Eastern, 1991.
2. M. S. Gopinathan and V. Ramakrishnan, Group Theory in Chemistry, Vishal Publishers, 1988.

Supplementary Reading:

1. J. D. Roberts, *Notes on M.O.Calculation*, McGraw Hill, 1990.
2. A. Streitweiser, Jr *Molecular Orbital for Organic Chemistry*, John Wiley & Sons, 1991.
3. David M. Bishop, *Group theory and Chemistry*, Dover, 1989.

CY 525 ADVANCED CO-ORDINATION CHEMISTRY 3 Credits [3-0-0]

Theories of metal-ligand bonding, Crystal field theory with respect to octahedral, tetrahedral and square planner, regular symmetry, distortion from regular system, John Teller effect. Ligand field theory. Spectral Properties : Selection rule, mechanism for breakdown of selection rule, absorption band width & shape, energy level diagrams, derivation of term symbols, nephelauxetic effect, Orgel and Tanabe-Sugano diagrams. Charge transfer spectra, Magnetic properties of complexes, Isomerism and stability of metal complexes. Mechanism of Inorganic Substitution Reactions : The nature of substitution reactions, Kinetic application of crystal field theory, Acid hydrolysis of octahedral cobalt Complexes, Effect of charge, chelation, steric crowding in determining the

mechanism. Base hydrolysis of octahedral cobalt complexes: Conjugate base and ion pair mechanisms, tests for conjugate base mechanisms. Mechanism of redox reactions. Mixed valence complexes. Modern aspects of crystal field theory, molecular orbital theory and valence bond methods applied to chemical, optical and magnetic properties of coordination compounds.

Essential Reading:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemsitry: Principles of Structure and Reactivity,* Pearson, 2006.
2. J. D. Lee, *Concise Inorganic Chemistry,* Blackwell Science, 1996

Supplementary Reading:

1. D. J. Newman, Betty, *Crystal Field,* Science, 2000
2. Emeleous & Sharpe*, Inorganic Chemistry,* Longman,1981.

CY 526 BIO- INORGANIC CHEMISTRY 3 Credits [3-0-0]

Metal ions in biology,their vital role in the active-site structure and function of metallo-proteins and enzymes especially those containing Mg, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo and W ions. Both heme and non-heme systems with one-, two- or multi-metal centers (e.g., Fe: Hb, Mb, Hr, P-450, MMO, ferridoxins, Fe-S clusters: Cu: hemocyanin, SOD, Mn: vitamin B12; Zn: CPA, CA, Ni: urease will also be highlighted. Focus will be on the metal environment (ligand type, coordination, geometry), electronic, magnetic and redox properties; functions such as electron – transfer, O_2-binding, reduction to O_2^-, O_2^{2-}, and O_2^- species their utilization in hydroxylation and epoxidation; fixation of N2, water-oxidation (Oxygen Evolving Complex) reactions.

Essential Reading:

1. G. N. Mukherjee and A. Das, *Elements of Bioinorganic Chemistry*,U.N. Dhar and Sons Pvt. Ltd., Kolkata, Revised Second Edition, 2002.
2. S. J. Lippard, and J. M. Berg, *Principles of Bioinorganic Chemistry*, Univ. Science Books, 1994.

Supplementary Reading:

1. D. E. Fenton, *Bio coordination Chemistry* (Chemistry Primer 26), Oxford Univ. Press, 1996.
2. L. Bertini, H. B. Gray, S. J. Lippard, and J. S. Valentine, *Bioinorganic Chemistry*, Univ. Science Books, 1994.

CY 527 SUPRAMOLECULAR CHEMISTRY 3 Credits [3-0-0]

From molecular to supramolecular chemistry: factors leading to strong binding, hydrogen bonding and stacking interactions. Molecular models of biological receptors, biomimetic chemistry, design, synthesis and binding studies of synthetic receptors. Metal guided self assembly reactions, molecular knot with double helical complexes of Cu(I). Self assembly of polynuclear metal complexes. New molecular receptors: crown ethers, siderophores, cyclophanes, cyclodextrin and their application in specific recognition processes. Anion coordination chemistry and recognition. Supramolecular reactivity and catalysis, supramolecular devices.

Essential Reading:

1. J. W. Steed and J.L.Atwood , *Supramolecular Chemistry* , CRC Press, 2004.
2. H. W. Roesky ,Rings, *Clusters & Polymers of the main group & Transition Elements*, Elsevier, 1989.

Supplementary Reading:

1. P. Beer, P. Gale and D.Smith , *Supramolecular Chemistry* (Oxford Chemistry Primers), 1999.
2. J. M. Lehn, *Supramolecular Chemistry*, VCH, 1995.

CY 531 THERMODYNAMICS AND CHEMICAL EQUILIBRIA 4 Credits [3-1-0]

Thermodynamics : Concept of system, exact differentials. First law of thermodynamics : energy and heat changes, Reversible processes, heat capacities, relation between Cp and Cv, Isothermal and adiabatic process, Joule-Thomson coefficient of ideal and real gases. Thermo Chemistry: Hess Laws, Heat changes of chemical reactions. Kirchoff's equation and its application, Calculation of heat of reaction from bond energy. Second Law of Thermodynamics. Elementary concept of entropy and free energy, Entropy and its variation with temperature, pressure and volume, entropy of mixing, Thermodynamic equation of state. Entropy and heat capacities relationship, Boltzmann-Plank equation for entropy. Work function, Gibb's Helmholtzs equation and its application, Carnot cycle, Heat engine. Third Law of Thermodynamics and its application to solid liquids and gases, Partial Molar Properties, Chemical potential and its variation with temperature and pressure, Fugacity. Chemical Equilibrium: Free energy and entropy, partial molar quantities, Equilibrium constant, Temperature – dependence of equilibrium constant, phase diagram of one – and two – component systems, phase rule.

Essential Reading:

1. G. N. Barrow, *Physical Chemistry,*TATA MCGRAW-HILL, 2007.
2. T. Engel, P.Reid, *Physical Chemistry,* Pearson, 2006.

Supplementary Reading:

1. K. L. Kapoor*, Text Book of Physical Chemistry,* MACMILLAN, 2006.
2. A. W. Atkins, *Physical Chemistry,* W. H. Freeman and Company, 1997.

CY 532 CHEMICAL KINETICS & PHOTOCHEMISTRY 4 Credits [3-1-0]

Chemical Kinetics : Methods of determining rate laws; Dependence of rate on concentration; Determination of order and rate constant from experimental data; Integrated rate expressions; Collision theory of reaction rates; steric factor, treatment of unimolecular reactions; Modified collision theory; Transition state theory; Chain reactions; Characteristic experimental features of chain reactions; Identification of a chain reaction; Normal and branched chain reactions; Theory of absolute reaction rates, comparison of results with Eyring and Arrhenius equations, ionic reactions; Salt effect; Mechanisms of photochemical, chain and oscillatory reactions; Homogeneous catalysis and Michaelis – Menten kinetics; - Lineweaver-Burk and Eadie plots, Effect of temperature and pH, inhibition effect, transient-phase kinetics, heterogeneous catalysis. **Kinetics in the excited electronic states** : Jablonskii diagram, Laws of light absorption, kinetics of unimolecular photophysical and photochemical processes, photostationary states, photoisomerisation, bimolecular photophysical and photochemical proceses: excimers, exciplexes and 77mmune77r777777ia. Mechanism of fluorescence quenching – Stern – Volmer equation, solar cells, photocatalysis, photosensitization, photo-initiated polymerization, epoxy polymers, photorefractive polymers supramolecules, dendrimers, photochromic compounds, Flash photolysis, Chemistry of vision.

Essential Reading:

1. M. R. Wright, *An Introduction to Chemical Kinetics,*John Wiley & Sons, 2005.
2. J. Raja Ram, and J. C. Kuriacose,*Kinetics and Mechanism of Chemical Transformations*, MacMillan Indian Ltd., New Delhi, 1993.

Supplementary Reading:

1. Richard I. Masel, *Chemical Kinetics & Catalysis*, Wiley-Interscience; 1st Edition, 2001.
2. K. K. Rohatgi-Mukherjee, *Fundamentals of Photochemistry*, Wiley, New York, 3rd Edition, 2002.

CY 533 QUANTUM CHEMISTRY 4 Credits [3-1-0]

Quantum Chemistry: Planck's quantum theory, wave – particle duality. Uncertainty Principle, operators and commutation relations; postulates of quantum mechanics and Schrodinger equation;

free particle, particle in a box, degeneracy, harmonic oscillator, rigid rotator and the hydrogen atom. Angular momentum, eigenvalues of angular momentum operator, ladder operators, orbital and spin motion of electron, coupling of angular momenta including spin-orbit coupling, Time-independent perturbation theory, degenerate states, variational method, Hellmann-Feynman theorem. Spectra and structure of helium atom, term symbols for atoms, Hartree-Fock equations, self-consistent field method and coupling schemes. Born-Oppenheimer approximation, hydrogen molecule ion, hydrogen molecule: valence bond and molecular orbital methods, polyatomic molecules and 78mmune78r787878ia. The concept of groups, symmetry operations and symmetry elements in molecules, matrix representations of symmetry operations, point groups, irreducible representations and character tables.

Essential Reading:

1. D. A. McQuarrie, *Quantum Chemistry*, University Science Books, 1983.
2. A. K. Chandra,*Introductory Quantum Chemistry,* Tata McGraw Hill,1979.
3. P. W. Atkins, Molecular Quantum Mechanics, 2nd edition, Oxford University Press, 1983.

Supplementary Reading:

1. Eyring, Walter & Kimbel ,*Quantum Chemistry,* John Willey,1953.
2. Fitts, D. Donald*, Principle of Quantum Mechanics,* Cambridge University Press, 1999.
3. I. N. Levine, *Quantum Chemistry*, 3rd edition, Allyn and Bacon, 1983.

CY 534 PRINCIPLE OF HETEROGENEOUS CATALYSIS 3 Credits [3-0-0]

Basic principles of catalysis, homogeneous and heterogeneous catalysis. Adsorptions: type of adsorption and their discrimination, adsorption isotherms, BDDT classification, surface area and pore size calculation, Enthalpy and entropy of adsorption, Langmuir, BET and other isotherms, Kelvin equation and capillary condensation. Kinetics: Kinetics of 78mmune78r78 reaction, various types of reactions such as simple, parallel and consecutive reaction, order of reaction, energy of activation. Catalyst preparation: Selection, preparation and evaluation of a catalyst, Effect of promoter, carrier, stabilizer, poisioning effect. Catalyst site characterization: Types of catalyst based on active sites, acid-base and redox catalysts, methods of determination of active sites (titration, TPD, TPR, FTIR etc.). Mechanism of catalyst action: Mechanism of selected reactions on catalyst surfaces such as hydrogenation, dehydrogenation, dehydration, cracking etc. Applications to selected industrial processes- petrochemical industry-reforming and refining, environment protection, value added chemicals, autoexhaust catalysis, pharmaceuticals. Novel nanosize catalysts: Novel nanosize catalytic materials- clusters, zeolites, Mesoporous materials, clays, composite oxides etc.

Essential Reading:

1. M. Thomas and W. H. Thomas, *Introduction to the principles of heterogeneous catalysis*, Academic press, London 2007.
2. G. A. Somorjai, *Introduction to surface chemistry and catalysis*, John Wiley and Sons 2006.

Supplementary Reading:

1. L. Augustine, *Heterogeneous catalysis for the synthetic chemist*. Marcel Dekker Inc., New York, 1996

CY 535 ELECTROCHEMISTRY 3 Credits [3-0-0]

Inter ionic attraction theory, Derivation of Debye Huckel Onsager's conductance equation, its verifications and modifications and its present trend. Determination of degree of dissociation of electrolyte. Theoretical calculation of activity coefficient from ionic strength by Debye-Huckel theory, Determination of activity coefficient from Freezing Point method, EMF method and solubility method. Ion association, determination of thermodynamic dissociation, constant of weak electrolytes by Shedlovsky method, Reversible cells, chemical and construction cells, Liquid junction potential, single electrode potential, oxidation – reduction electrodes. Determination of (i) dissociation constant of weak monobasic acid (ii) hydrolysis constant of salts (iii) ionic product of water and (iv) solubility product of sparingly spoilable salts by EMF measurements. Factors effecting

the EMF of half cells, Determination of pH. Electrode concentration cells, Electrolyte concentration cell. Electrochemical series and its significance,. Electrolytic polarization, over voltage.

Essential Reading:

1. S. Glasstone, *Text Book of Physical Chemistry*, MACMILLAN 1974.
2. G.M. Barrow , *Physical Chemistry*, TATA MCGRAW-HILL ,2007

Supplementary Reading:

1. Books and Reddy, *Modern Electrochemistry,* Vol – I .Springer,2000.
2. W.J. Moore, *Physical Chemistry*, Prentice Hall,1993

CY 536 COLLOIDS AND SURFACE CHEMISTRY 3 Credits [3-0-0]

The colloidal state: Introduction; Classification and colloidal systems; Properties of 79mmune79r79 and lyophobic colloidal solutions. Structural characteristics; Preparation and purification of colloidal systems. Kinetic properties: The motion of particles in liquid media; Brownian motion and translational diffusion; Osmotic pressure; Rotary Brownian motion. Optical properties: Optical and electron microscopy; Light scattering; Tyndall effect- turbidity. Liquid-gas and liquid-liquid interfaces; Surface and interfacial tensions; Adsorption and orientation at interfaces; Association colloids-micelle formation; spreading; Surface films and Langmuir-Blodgett films. Properties and aggregation of surfactants; The solid-gas interface: Adsorption of gases and vapours on solids; Capillary condensation; Langmuir adsorption isotherm; BET equation for multimolecular adsorption; Composition and structure of solid surfaces. The solid-liquid interface; Contact angles and wetting; Detergency; Adsorption from solution. Charged interfaces: The electric double layer; Electrokinetic phenomena; Electrokinetic theory. Colloid stability: Lyophobic sols; van der Waals forces between colloidal particles; Rheology: Introduction; Viscosity; Non-Newtonian flow; Viscoelasticity. Emulsions and foams: Oil-in-water and water-in-oil emulsions; Emulsifying agents and emulsion type; gels and Foams.

Essential Reading:

1. R. M. Pashley, and M. E. Karaman, *Applied Colloid and Surface Chemistry*, John Wiley & Sons Ltd., 2004.
2. D. Shaw, and B. Heinemann, *Introduction to Colloid and Surface Chemistry*, Butterworth Heinemann, 4th Edition, 1992.

Supplementary Reading:

1. E. D. Shchukin, A. V. Pertsov, E. A. Amelina, and A. S.Zelenev, *Colloid and Surface Chemistry,*Elsevier, 2001.
2. F. Caruso (Editor),*Colloids and Colloid Assemblies: Synthesis, Modification, Organisation and Utilization of Colloid Particles*, Wiley, 2004.

CY 537 ADVANCED SOLID STATE CHEMISTRY 3 Credits [3-0-0]

Introduction, Crystal structure, Crystalline solids, Crystal systems, Metallic structure-Unit cells, Crystallographic directions and planes, linear and planar densities, close-packed crystal structures, Types of close packing-hcp and ccp, packing efficiency, Ceramics structure- radius ratio, structure types-NaCl, ZnS, Na_2O, $CdCl_2$, wurtzite, nickel arsenide, CsCl, CdI_2, rutile, Perovskite ABO_3 and Spinels AB_2O_4. Material preparation-Solid state reactions, precipitation, sol-gel route, precursor method, Ion exchange reactions, Intercalation/deintercalation reactions, soft chemical reactions and thin film preparation, Method of characterization-Powder X-ray diffraction, electron and Neutron diffraction, Thermal analysis, microscopic and spectroscopic techniques as tools for material characterization, Phase diagram and microstructure analysis- simple binary isomorphous, eutectic and congruent phase diagrams, Electronic properties-Developments, free electron theory, Band Theory, metals and their properties, Semiconducors- intrinsic and extrinsic, Hall Effect, Insulators-dielectric, ferroelectric, pyroelectric and Peizoelectric properties, Magnetic properties-Dia, para, ferro, ferri, antiferro and antiferri materials, Defects and dislocations-Vacancies and interstitials, dislocations

and grain boundaries colour centers and reactivity, Amorphous materials-glasses and refractories, Superconductivity-Theory, discovery, various high Tc materials, Novel materials-Zeolites, Heteropoly acids, Mesoporous materials (MCM-41, MCM-48, SBA, TS), fullerenes, carbon nanotubes etc

Essential Reading:

1. A. R. West, *Solid state Chemistry and its applications,* Wiley Student Edition (John Wiley & Sons), 1988
2. C. N. R. Rao and J. Gopal Krishnan,New directions in solid state Chemistry, Cambridge press, 1990

Supplementary Reading:

1. A. F. Wells, *Structural Inorganic Chemistry,*Oxford University Press, USA; 5 Edition, 1984.

CY 538 MOLECULAR SPECTROSCOPY 3 Credits [3-0-0]

Interaction of matter with radiation, time dependent perturbation theory, Einstein coefficients. **Energy levels and transition probabilities** for the rigid rotor – harmonic oscillator model, potential energy surfaces in the ground and excited electronic states, Franck-Condon principle, spectroscopy of diatomic molecules (rotational, vibrational and electronic). Anharmonicity and centrifugal effects, Dunham expansion and Morse oscillator. **Rotational and vibrational spectroscopy** of polyatomic molecules, angular momentum operator matrix elements, energy levels and transition probabilities for symmetric and asymmetric top molecules, normal modes of vibration and their classification by group theory. Coupling between rotational and vibrational degrees of freedom: elementary introduction. Electronic spectra of polyatomic molecules: absorption and emission spectroscopy, charge transfer spectra, effect of solvent, Raman spectroscopy, Introduction to Mossbauer, photoelectron nuclear magnetic resonance spectroscopy. **Electron Spin Resonance Spectroscopy**: Electronic Zeeman and hyperfine interactions, hydrogen atom in a magnetic field, selection rules in ESR, anisotropy and hyperfine constants, hybridization, ESR of organic free radicals in solution, McConnell's relations.

Essential Reading:

1. C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata- McGraw-Hill, 1994.
3. P. S. Sindhu, *Fundamentals of Molecular Spectroscopy*, New Age International (p) Limited, 2008.

Supplementary Reading:

1. Peter F. Bernath, *Spectra of Atoms and Molecul*es, Oxford University Press, 1995.
2. J. M. Hollas, *Modern Spectroscopy*, Wiley, 1992.
4. C. Harris and M. D. Bertolucci, *Symmetry and Spectroscopy*, Dover, 1989.

CY 539 BIOPHYSICAL CHEMISTRY 3 Credits [3-0-0]

Hydrophobic and hydrophilic interactions in biological systems, biological relevance of chemical potential, protein solvent interactions-binding, hydration and exclusion, protein structure, stability, folding, unfolding and their spectroscopic and calorimetric studies. Protein ligand binding, equillibria across membranes, structure-function relationships.

Essential Reading:

1. R. B. Gregory, *Protein solvent interactions*, Marcel Dekker, Inc. 1995.
2. B. T. Nall and K. A. Dill, *Conformations and forces in protein Folding*, American Association for the Advancement of science, 1991.

Supplementary Reading:

1. C. R. Cantor and P. R. Schimmel, *Biophysical Chemistry Part-III*, Freeman and Co. 1980.

CY 541 CHEMISTRY OF HETEROCYCLIC COMPOUNDS 3 Credits [3-0-0]

Introduction, Structure and uses of heterocycles, Synthesis and Reactivity of furan, thiophene, pyrrole, pyridine, 81mmune81r81, isoquinoline, indoles, azines, purines, pteridines, azoles, benzo-fused ring systems including isobenzofuran, heteroisobenzofurans, compounds withoxygen and sulfur hetero atoms and small-ring heterocycles. Role ofheterocyclic compounds in biological systems.

Essential Reading:

1. T. L. Gilchrist, *Heterocyclic Chemistry*, Pearson Education, 3rd Ed. 2007.
2. J. A. Joule and G. F. Smith, *Heterocyclic Chemistry*, ELBS, 1978.

Supplementary Reading:

1. A. R. Katritzky and Pozharskii, *Handbook of Heterocyclic Chemistry* Academic Press; 2nd Ed. 2000.
2. J. A. Joule and K. Mills, *Heterocyclic Chemistry*, Wiley-blackwell; 4th Ed, 2000.

CY 542 METHODS INORGANIC SYNTHESIS 3 Credits [3-0-0]

The disconnection approach, chemoselective synthesis,C-C bond forming reactions, organometallic reagents in organic synthesis: Grignard reagents, organolithium reagents, organocadmium reagents, organocopper reagents, organosilicon compounds, organotin compounds, organoaluminum compounds, organoiron compounds, organochromium reagents, ylides of sulfur, phosphorous and nitrogen. Tebbe's reagent. Enolates, kinetic and thermodynamic enolates, enolate condensation reactions like Claisen, Dieckmann, Knoevenegal, Stobbe, Darzen glycidic ester. Umpolung reagents, definition of umpolung, acyl anion equivalent, equivalents of ketene, $RCOCH_2^+$, $RCOCH_2CH_2CH_2^+$, $RCOCH_2CH_2CH_2^-$ etc. Protecting groups: protection of hydroxyl, carboxyl, carbonyl, amino groups. Protection of carbon-carbon multiple bonds. Illustration of protection and deprotection in synthesis.

Essential Reading:

1. S. Warren, *Organic Synthesis: The Disconnection Approach*, Wiley Student Ed. 2007
2. J. Singh, L. D. S. Yadav, Organic Synthesis, Pragati Prakashan, 2007.
3. Michael B. Smith, *Organic Synthesis*, McGraw Hill, 2004.

Supplementary Reading:

1. S. Warren, *Designing Organic Synthesis*, John Wiley, 1978
2. S. G. Davies, *Organotransition Metal Chemistry, Application to Organic Synthesis*, Pergamon Press, 1982.
3. R. K. Mackie and D. M. Smith, *Guidebook to Organic Synthesis*, ELBS, 1982.

CY 543 MOLECULAR REARRANGEMENT 3 Credits [3-0-0]

Aldol Condensation, Claisen condensation, Dieckmann condensation, Curtius, Schmidt, Lossen and Wolff Reaction, Cope Reaction, Chugaev Reaction, Perkin, Stobb, Hofmann, Schidmt, Curtius, Reimer-Tiemann, Reformatsky, Diels-Alder reaction, Friedel-craft reaction, Wittig reaction, Meerwein-Pondroff-Verley reduction, Clemmenson reduction, Wolf-Kishner reduction, Birch reduction, Baylis-Hilman reaction, Barton reaction, Bamford-Stevans reaction, Shapiro reaction, Heck reaction, Demijanov, Pinacol-Pinacolone rearrangement, Favorski Rearrangement, Fries rearrangement, Wagner-Meerwein Rearrangement, Benzil-Benzilic Acid Rearrangement, Beckmann Rearrangement, Claisen rearrangement, Bamberger rearrangement, Suzuki coupling, Stille coupling, McMurry coupling, Sonagashira coupling.

Essential Reading:

1. Parikh, Parikh and Parikh, *Name reactions in Organic Synthesis,* Foundation Books, 2006.
2. G. Brahmachari, Organic Name Reactions, Narosa Publishers, 2009.

Supplementary Reading:

1. Robert and Cassenio*, Basic Principles of Organic Chemistry,* Addison-Wesley Pub1977.
2. J. J. Li*, Name reactions in organic synthesis ,* 3rd Edition, SPRINGER 2006.
3. M. Smith, *Organic Synthesis,* Mc Graw Hill, 2nd Ed. 2004.

CY 544 INSTRUMENTAL METHODS OF ANALYSIS 3 Credits [3-0-0]

Basic principle, Instrumentation and application to chemist of the following instruments Atomic absorption spectroscopy, Flame emission spectroscopy, XRD, XRF. Polarography, Cyclic Voltametry, Basic principle and general analytical application of Thermal analysis, TGA and DTA, DSC Thermometric titration, Theory, instrumentation and complexation titrations dealing with EDTA., Principle, instrumentation and general application of Chromatography., Flow injection analysis, Recent development in the above technique.

Essential Reading:

1. A. S. Douglas, F. J Holler, S. R. Crouch, *Principles of Instrumental Analysis*, Thomson, 2007.
2. Willard, Merritt and Dean , *Instrumental Methods of Analysis*, AFFILIATED EAST-WEST, New Delhi, 2004

Supplementary Reading:

1. A. S. Douglas, F. J Holler, S R Crouch *Fundamentals of Analytical Chemistry*, Thomson, 2007.
2. R. S. Drago *Physical methods in inorganic chemistry*, AFFILIATED EAST-WEST, New Delhi, 1988.

CY 558 ORGANOMETALLIC CHEMISTRY 3 Credits [3-0-0]

General introduction, Structure and bonding, 18-Electron rule, Wades rule, Survey of organometallic complexes Preparation, properties and bonding of metal carbonyl complexes, Bonding in carbonyls, nitrosyls, tertiary phosphines, hydrides, alkene, alkyne, cyclobutadiene, cyclopentadiene, arene compounds and their M.O. diagrams. Metal-carbon multiple bonds. Fluxional organometallic compounds including ð-allyl complexes and their characterization. Metallocycles, unsaturated nitrogen ligands including dinitrogen complexes. Preparation and applications of organomagnesium compounds, Organolithium compounds, organocopper reagents, organozinc compounds, organolead compounds, organoaluminum compounds, organosilanes and organoboranes towards organic tranformations. Metal-Metal bond and transition metal cluster, Organometallic catalysis.

Essential Reading:

1. B. F.G. Johnson, *Transition metal cluster*, Wiley, 1980.
2. R. C. Mehrotra and A. Singh, *Organometallic Chemistry-A unified approach*, New age international(P)limited publisher, 2001.
3. C. Elschenbroich and A, Salzer, *Organometallic-A Concise introduction*, Weinheim, 1992.

Supplementary Reading:

1. R.H. Crabtree, *The organometallic chemistry of the transition metals*, Wiley-Interscience, 2005.
2. G. Wikinson, F.G.A. Stone, E. Abel, *Comprehensive Organometallic Chemistry*, Peramon, 1980.
3. P. Powell, *Principle of Organometalic Chemistry*, Kulwar, 1991.

CY 571 ORGANIC CHEMISTRY LABORATORY 6 Credits [0-0-9]

Elemental Analysis of Organic Compounds (C, H, N, O, S), Identification of organic compounds having at least two functional groups; Preparation of (a) p-Iodo tolune, (b) Benzaldehyde to Benzoin →

Benzil → Benzilic acid, (c) Benzoic acid → o-Benzoyl Benozoic acid → Anthraquinone → Anthrone, (d) Ethylacetate → Ethylaceto acetate, I Anisole → Phenacetin; Synthesis of a simple dye and check, its purity by paper chromatography and extinction coefficient measurement; Estimation : (a) Methoxy group, (b) Acetyl group, (c) Nitrogen, (d) Carbon and hydrogen, I Spectrophotometric analysis of Keto group

Essential Reading:

1. V. K.Ahluwalia and R. Aggarwal, *Comprehensive practical organic chemistry*, University press. 2000
2. B. S. Furniss, *Vogel's Text Book of Practical Organic Chemistry*, ELBS Longman, 5th Edition, 1996.

Supplementary Reading:

1. D. S. Gupta , *Experimental Organic Chemistry, Qualitative and Quantitative*, TATA MCGRAW HILL 2004
2. A. Ault, *Techniques and Experiments for Organic Chemistry*, University Science Book.1998

CY 572 INORGANIC CHEMISTRY LABORATORY 6 Credits [0-0-9]

Semimicro qualitative analysis (anions are excluded) and quantitative estimations (Polarography, Amperometry & Biamperometry, Potentiometry, spectrophotometry, Turbidimetry, Electrogravimetry, pH metry and Flame photometry), synthesis (air-sensitive, moisture-sensitive etc.,), characterization and property measurements of inorganic (especially coordination) compounds, Exposure to various spectroscopic characterization techniques.

Essential Reading:

1. In-house laboratory manual and relevant literature
2. G. Svehla, Vogel's qualitative inorganic analysis, Harlow Longman, 2002.
3. A. I. Vogel, John Bassett, Vogel's textbook of quantitative inorganic analysis: including elementary instrumental analysis, Longman, 2003

Supplementary Reading:

5. A. I. Vogel, Qualitative Inorganic Analysis, Orient Longman – 1979.

CY 573 PHYSICAL CHEMISTRY LABORATORY 6 Credits [0-0-9]

Conductometric titrations: Dissociation constant of weak acid, solubility product of sparingly soluable salt ($PbSO_4$, $BaSO_4$), Determination of strength of strong and weak acids in a given mixture conductrometrically, Determination of ratio of Potasium Dicromate, chromate in a supplied mixture. Potentiometric titration: Determination of Dissociation Constant of weak acid Determination of pH of an electrolyte. Polarimetricdetermination of Concentration of unknown sugar solution Inversion of cane sugar; Determination of Co-ordination number of copper in cupramine complex by distribution method, determination of Equilibrium constant of the reversible reaction $KI + I_2 = KI_3$, Kinetics of Easter Hydrolysis by acid and base; Determination of Molecular mass of volatile liquids by Victor Meyer Method. Determination of Molecular mass of inorganic solids by Rast's method, Determination of magnetic moment by Gouy's balance.

Essential Reading:

1. B. Behera *, Experimental Physical Chemistry, ,* Tata McGraw Hill 2000.

Supplementary Reading:

1. D. Alart, *Practical Physical Chemistry*, Longman, 1993.

CY 574 ENVIRONMENTAL CHEMISTRY LABORATORY 6 Credits [0-0-9]

Physico-chemicalanalysis of water and waste water analysis ; Analysis of Soil parameters ; Analysis of air & Noise

Essential Reading:

1. N. Manivaskam*, Physico-Chemical Examination of Water, sewage and Industrial Effluences,* Pragatiprakashan, 2000.

Supplementary Reading:

1. *Standard Methods for the Examination of Water and Waste Water,* APHA, AWWA, 6th Edition, 2002.

DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES

DETAILED SYLLABI OF COURSES

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	ER 201	Physics of Atmosphere	3-0-0	3
2	ER 202	Evolution of Early Earth	3-0-0	3
3	ER 203	Coal and Petroleum Geology	3-0-0	3
4	ER 204	Global Plate Tectonics	3-0-0	3
5	ER 205	Introduction to Weather and Climate	3-0-0	3
6	ER 207	Mining Geology	3-0-0	3
7	ER 511	Physical Geology	3-0-0	3
8	ER 512	Crystallography & Mineralogy	3-0-0	3
9	ER 513	Structural Geology	3-0-0	3
10	ER 514	Geochemistry	3-0-0	3
11	ER 515	Igneous & Metamorphic Petrology	3-1-0	4
12	ER 516	Sedimentary and Quaternary Geology	3-1-0	4
13	ER 517	Stratigraphy	3-0-0	3
14	ER 518	Palaeontology	3-0-0	3
15	ER 519	Fuel and Economic Geology	3-1-0	4
16	ER 520	Hydrogeology	3-0-0	3
17	ER 521	Engineering Geology	3-0-0	3
18	ER 522	Remote Sensing & GIS	3-0-0	3
19	ER 523	Geology of Fuels	3-0-0	3
20	ER 524	Environmental Geology	3-0-0	3
21	ER 525	Isotope Geology	3-0-0	3
22	ER 526	Geophysical Methods	3-0-0	3
23	ER 527	Geostatistics	3-0-0	3
24	ER 528	Introduction to Atmosphere and Ocean Science	3-0-0	3
25	ER 529	Tectonic Geodesy: Crustal Deformation & Active Tectonics	3-0-0	3
26	ER 530	Rheology of the Earth	3-0-0	3
27	ER 531	Earthquake and Volcano Deformation	3-0-0	3
28	ER 532	Weather and Climate Systems	3-0-0	3
29	ER 601	Theoretical Meteorology	3-0-0	3
30	ER 602	Applied Atmospheric Dynamics	3-0-0	3
31	ER 603	Introduction to Climate Science	3-0-0	3
32	ER 604	Boundary Layer Meteorology	3-0-0	3
33	ER 605	Introduction to Microscale and Mesoscale Meteorology	3-0-0	3
34	ER 606	Mesoscale Meteorology and Modeling	3-0-0	3
35	ER 607	Application of Tectonic Geodesy	3-0-0	3
36	ER 608	Rock Water Interaction	3-0-0	3
37	ER 609	Geochronology	3-0-0	3
38	ER 610	Applied Isotope Geology	3-0-0	3
39	ER 611	Instrumentation for Earth Scientists	3-0-0	3
40	ER 612	Petroleum Geology	3-0-0	3
41	ER 613	Coal Geology	3-0-0	3
42	ER 614	Geostatistics	3-0-0	3
43	ER 615	Applied Hydrogeology	3-0-0	3

44	ER 616	Satellite remote sensing for geo-resource evaluation	3-0-0	3

ER 201 PHYSICS OF ATMOSPHERE 3 Credits [3-0-0]

State of the atmosphere; Constituents of air; Structure of Atmosphere; Importance of solar radiation in Earth's atmosphere; Characteristics of solar radiation; Definitions and concepts in radiation; Transfer of radiation through a medium; Terrestrial radiation; Characteristics of terrestrial radiation; Absorption of terrestrial radiation; Transmission of terrestrial radiation through the atmosphere; Radiative cooling or heating of the atmosphere; Overview of Earth's radiation budget

Thermodynamics of dry air: Equation of state, Expansion of gas under constant pressure; Law of conservation of energy; specific heats of a gas; First law of thermodynamics; Adiabatic process in the atmosphere; Potential temperature; Equation state of dry air; poisson's equation for dry air; Alternative forms of the energy equation; Entropy; Enthalpy.

The thermodynamics of water vapour and moist air: The three states of water substances; The Classius and Clapeyron equation; Equation of state for water vapour; Moisture variables (Absolute humidity, specific humidity, relative humidity, mixing ratio); Virtual temperature.

Environmental lapse rate, Standard atmosphere, Hydrostatic equilibrium, Hydrostatic equation, Vertical stability of the atmosphere: Dry adiabatic lapse rate; Standard adiabatic lapse rate; Equilibrium states; The parcel method; Application of the parcel method, The slice method, Cumulous clouds and bubble theory, Radiative heating and cooling of clouds; Convection and Rainfall; Introductory idea of weather systems and physical climate

Essential Reading:

1. Hess S. L. (1959): Introduction to Theoretical Meteorology, Krieger Publishing Company Malabar, Florida
2. Lynch A. H. and and J. J. Cassano (2005): Applied Atmospheric Dynamics, John Wiley and Sons Ltd

Supplementary Reading:

3. Haltiner G. J. and F.L.Martin (1957): Dynamical and Physical Meteorology, McGraw-Hill Publcations,
4. Houghton H. G. (1985): Physical Meteorology, MIT Press
5. Iribarne J. V. and W.L.Godson (1981): Atmospheric Thermodynamics, Springer

ER 202 EVOLUTION OF EARLY EARTH 3 Credits [3-0-0]

Formation of our solar system; Nucleosynthesis; Comparison of Earth with other planets; Sedimentary and Ore deposits; Radiometric age dating; Onset and evolution of life; Continent formation and their reconfiguration; Marine anoxia; Abundance and distribution of redox-sensitive elements; Stable and non-traditional isotopes; Seawater iron and oxygen; Atmospheric oxygen level and its temporal trend.

Essential Readings:

1. S. E. Kesler and H. Ohmoto (2006): Evolution of Early Earth's atmosphere, hydrosphere, and Biosphere-Constrains from Ore deposits, Geological society of America Memoir 198.

2. H. Rollison, Early Earth Systems (2006): A Geochemical approach, Wiley-Blackwell Publishers.

Supplementary Reading:

1. D. C. Catling and M. W. Clarie, How Earth's atmosphere evolved to an oxic state: A status report. Earth and Planetary Science Letters, 237, 1-20, 2005.

2. H D Holland (1984): The chemical evolution of the atmosphere and oceans, Princeton university.
3. W Altermann, P L Cocoran, Precambrian sedimentary environment (2002): A modern approach to ancient deposational systems, Blackwell science publishers.

ER 203 COAL AND PETROLEUM GEOLOGY 3 Credits [3-0-0]

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).

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.

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.

Coal Bed Methane (CBM) – Non Conventional clean energy resources.; Elementary idea about generation of methane in coal beds; coal as a reservoir and coal bed methane /Coal Mine Methane Shale gas etc exploration

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.

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).

Oilfields of India.

Essential Readings:

1. Chandra, D., Singh, R.M. Singh, M.P. (2000): Textbook of Coal (Indian context), Tara Book Agency, Varanasi.

2. Thomas, Larry (2002): Coal Geology, John Wiley and Sons Ltd., England
3. Holson, G.D. and Tiratso, E.N. (1985): Introduction of Petroleum Geology, Fulf Publishing, Houston, Texas
4. Selley, R.C. (1998): Elements of Petroleum Geology, Academic Press.

Supplementary Reading:

1. Scott, A.C. (1987): Coal and Coal-bearing strata: Recent Advances, Blackwell Scientific Publications.
2. Stach;, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R. (1982): Stach.
3. Barker, C. (1996): Thermal Modeling of Petroleum Generation, Elsevier Science, Netherlands.
4. Jahn, F., Cook, M. and Graham, M. (1998): Hydrocarbon exploration and production, Eslevier Science
5. Tissot, B.P. and Welte, D.H. (1984): Petroleum Formation and Occurrence, Springer–Verlag.
6. 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.
7. North, F.K. (1985): Petroleum Geology, Allen Unwin.

ER 204 GLOBAL PLATE TECTONICS 3 Credits [3-0-0]

Historical perspective, The interior of the Earth, Continental drift, Sea floor spreading and transform faults, The framework of plate tectonics, Ocean ridges, Continental rifts and rifted margins, Continental transforms and strike-slip faults, Subduction zones, Orogenic belts, Precambrian tectonics and the supercontinent cycle, The mechanism of plate tectonics, Implications of plate tectonics and current trend of research.

Essential Readings:

1. Global Tectonics, 3rd Edition, by P.Kearey, K.A. Klepeis, F.J.Vine, (2009), Wiley-Blackwell.
2. Plate Tectonics Continental Drift and Mountain Building, by Martin Meschede, Ronald C. Blakey, Wolfgang Frisch (2011), Springer

Supplementary Reading:

1. Geodynamics, 2nd Edition, by D.L. Turcotte and G. Schubert, (2008), Cambridge University press.
2. Plate Tectonics and crustal evolution, by K.C. Condie, (1997), Butterworth-Heinemann.

ER 205 INTRODUCTION TO WEATHER AND CLIMATE 3 Credits [3-0-0]

Wind systems in atmosphere; Tropical and extra tropical weather systems; Clouds and severe weather; Tropical weather; Mountain weather; Polar weather; Clouds and precipitation; Condensation and precipitation processes; Heat and temperature changes; Radiation and exchange of heat; Showers, thunderstorms, hail and tornadoes; Haze, Mist, Smog and Fog; Local wind systems; The major wind systems; Air masses; Fronts and frontogenesis; Over view of the severe convective

storms, Cyclonic systems, tornadoes and tornadic storms; Tropical disturbances, storms and hurricanes; Temperature regimes; Precipitation regimes; World climates; Modifying weather and climate; Climate Change; Natural causes of climate change; Anthropogenic climate change and the future

Essential Readings:

1. Lynch A. H. and and J. J. Cassano (2005): Applied Atmospheric Dynamics, John Wiley and Sons Ltd.
2. Critchfield H. J. (1992): General Climatology, 4th Edition, Prentice Hall of India Pvt. Ltd, New Delhi, India

Supplementary Reading:

1. Roland Stull (2000): Meteorology (for scientists and engineers), Second edition, Brooks/Cole Thomson Learning.
2. C. Donald Ahrens (1988): Meteorology Today (An introduction to weather, climate and environment), Third Edition, West Publishing Company.

ER 207 MINING GEOLOGY 3 Credits [3-0-0]

Introduction to Geology: its scope and application to engineering problems, Physical Geology, Mineralogy - Determinative properties and occurrence of common rock forming minerals in India, Petrology - Igneous, Sedimentary and Metamorphic rocks; Structural Geology: Elementary knowledge of rock deformation and structural characteristics of deformed rocks, strike, dip, folds and faults, their description, classification, Joints, Un-conformities/simple forms of igneous rocks, Dykes, sills, etc., Geological maps and their interpretation, Stratigraphy - Principles of Stratigraphy, Standard Stratigraphic Scale, Indian Stratigraphy; Economic minerals: their classification, origin, mode of occurrence, geographical and geological distribution, physical properties and industrial uses and distribution of major metallic and non-metallic mineral deposits of India. Origin and distribution of natural fuels - Coal, Petroleum and natural gas, nuclear fuels.

Essential Reading:

1. P. K. Mukherjee, *A Text Book of Geology*, The World Press Pvt. Ltd., 9th Edition, 1982.
2. H. H. Read, *Rutley's Elements of Mineralogy*, CBS Publishers and Distributors, 26th Edition, 1984

Supplementary Reading:

1. P. B. Marland, *Structural Geology*, Prentice Hall of India Pvt. Ltd., 3rd Edition, 1990.
2. D. E. Salisbury & W. E. Ford, *A Text Book of Mineralogy*, Wiley Eastern Limited, 4th Edition, 1992.
3. G.W. Tyrrel, *The Principles of Petrology*, B.I. Publications Pvt. Ltd., 1989.
4. G. B. Mahapatra, *Text Book of Physical Geology*, CBS Publishers and Distributors, 1st Edition, 1990.
5. R. Kumar, *Fundamentals of Historical Geology and Stratigraphy of India*, Wiley Eastern Limited, 1992.

ER 511 PHYSICAL GEOLOGY 3 Credits [3-0-0]

Origin and Age of the Earth; Geological time-scale; Earth's internal structure; Earthquakes and seismic waves; Volcanoe, Earth's magnetic and gravity fields; Palaeomagnetism. Continental Drift; Sea-floor spreading; Plate Tectonics; Island Arcs, Mid-oceanic Ridge, Isostasy, Structure of Atmosphere and related phenomena; Geological Hazards; Origin and Evolution of ocean basins, Ocean Circulation, Global Warming; Geological processes operating on the surface of earth. Landforms produced by actions of river, wind, groundwater, glacier and wave; Coastal geomorphology.

Essential Reading:

1. Kent C. Condie**,** *Earth as an Evolving Planetary System,* Academic Press; 2nd edition, Second Edition, 2010.
2. H. Jay Melosh, *Planetary Surface Processes,* Cambridge University Press; 1st edition, 2011.

Supplementary Reading:

1. William Lowrie, *Fundamental of Geophysics,* Cambridge University Press, 2nd edition, 2007.

ER 512 CRYSTALLOGRAPHY & MINERALOGY 3 Credits [3-0-0]

Crystallography, Unit Cells, Symmetry Elements, Crystal Systems, Miller Indices, Crystal Habit, Stereographic Projection of Crystals, Silicate Structure, Chemical and Physical Properties of common rock-forming minerals, Twinning, Optical Mineralogy, Uniaxial and Biaxial Minerals, Optical Properties of common rock-forming minerals, application of mineral physics in earth sciences, phase transitions, LPO and seismic anisotropy etc.

Essential Reading:

1. L.G. Berry, B. Mason, and R.V. Dietrich, *Mineralogy*, CBS Publ, 1982.
2. E.S. Dana and W.E. Ford, *A textbook of Mineralogy* (Reprint), 2002.

Supplementary Reading:

1. D. W. Nesse, *Optical Mineralogy*, McGraw Hill, 1986.
2. D. Perkins, *Mineralogy,* Prentice Hall, 1998.
3. P.F. Kerr, *Optical Mineralogy,* McGraw Hill, 1977.

ER 513 STRUCTURAL GEOLOGY 3 Credits [3-0-0]

Dynamic and kinematic analyses of rocks in two dimensions, Stress and Strain Ellipsoid. Plastic and Brittle Deformation, Rheology, Petrofabric Analysis, Dip and Strike, Fold- Parts, Classification, Mechanism of folding, Superimposed folding and interference pattern, Fault – Parts, Classification and Mechanism of faulting, Thrust tectonics, Lineaments, Joints, Unconformity, Micro-deformation, Shear zones, GPS and active tectonics, earthquake & volcano deformations.

Essential Reading:

1. Haakon Fossen, *Structural Geology,* Cambridge University Press; 1 edition, 2010.

2. G. H. Davis, S. J. Reynolds, C. F. Kluth, *Structural Geology of Rocks and Regions,* Wiley; 3 edition, 2011.
3. J. Jaeger, N. G. Cook and R. Zimmerman, *Fundamentals of Rock Mechanics,* Wiley-Blackwell; 4th edition, 2007.

Supplementary Reading:

1. J.G. Ramsay and M.I. Huber, *Techniques of Modern Structural Geology, Vol. I, Strain Analysis,* Academic Press, 1983.
2. J.G. Ramsay and M.I. Huber, *Techniques of Modern Structural Geology, Vol. II, Folds and Fractures,* Academic Press, 1987.
3. J.G. Ramsay and M.I. Huber, *Techniques of Modern Structural Geology, Vol. III (Application of continuum mechanics),* Academic Press, 2000.

ER 514 GEOCHEMISTRY 3 Credits [3-0-0]

Earth in relation to the solar system and universe; cosmic abundance of elements; Composition of meteorites; Structure and composition of earth and distribution of elements; Polymorphism; Isomorphism; Elementary crystal chemistry; Chemical thermodynamics; Geochemical classification of elements; Geochemistry of hydrosphere, biosphere and atmosphere; Weathering of rocks; Surface chemistry; Oxidation and Reduction reactions; Introduction to isotope geochemistry; Reaction rates and mass transfer.

Essential Reading:

1. K. B. Krauskopf and D. K. Bird, *Introduction to Geochemistry,* McGraw-Hill, 1995.
2. C.A.J. Appelo, D. Postma, *Geochemistry, Groundwater and Pollution*, Taylor & Francis; 2nd edition, 2005.

Supplementary Reading:

1. J. V. Walter, Essentials of Geochemistry, Jones and Bartlett, 2010
2. J. I. Drever, The Geochemistry of Natural Waters, Prentice Hall, 1997

ER 515 IGNEOUS & METAMORPHIC PETROLOGY 4 Credits [3-1-0]

Forms, textures and structures of igneous rocks; Silicate melt equilibria; binary and ternery phase diagrams; Effect of P, T and fluid on melting; Norms – CIPW, Niggli values; Chemical Petrology; Petrology and geotectonic evolution of granites, basalts, andesites and alkaline rocks; Petrology of gabbros, kimberlites, anorthosites and carbonatites; Origin of primary basic magmas. Textures and structures of metamorphic rocks; Regional and contact metamorphism of pelitic and calcareous rocks; Metamorphic Mineral assemblages and chemographic (ACF, AKF and AFM) diagrams; Metamorphic reactions; Characteristics of diferent grades and facies of metamorphism; Metasomatism and granitization; migmatites;. Plate tectonics and metamorphic zones; Paired metamorphic belts.

Essential Reading:

1. Myron G. Best, *Igneous and Metamorphic Petrology,* Wiley-Blackwell; 2nd edition, 2002.
2. John D. Winter, *Principles of Igneous and Metamorphic Petrology,* Prentice Hall; 2nd edition, 2009.
3. Anthony Philpotts and Jay Ague, *Principles of Igneous and Metamorphic Petrology,* Cambridge University Press; 2nd edition, 2009.

Supplementary Reading:

4. Anthony Hall, *Igneous Petrology*, Longman Sci. & Tech, 1987.
5. Powell, R., *Equilibrium thermodynamics in Petrology: An Introduction,* Harper and Row Publ., London, 1978.

ER 516 SEDIMENTARY AND QUATERNARY GEOLOGY 4 Credits [3-1-0]

Process of formation of sedimentary rocks, Elements of Sedimentary Basins, Transport of sediment grains, Mechanics of sediment transport and transport laws, Sedimentary Structures: grain size parameters and distribution, grain shape and form, Biogenic, chemical and volcanogenic sediments, Definition of Quaternary, Quaternary Stratigraphy of India- continental records, marine records, Quaternary Stratigraphy: Oxygen Isotope Stratigraphy, biostratigraphy and magnetostratigraphy, Quaternary dating methods-radiocarbon, Uranium series, Luminescence, Amino acid, relative dating methods, Quaternary climates, Proxy indicators of paleoenvironmental/paleoclimatic changes.

Essential Reading:

1. Maurice Tucker, *Sedimentary Petrology,* Wiley-Blackwell; 3rd edition, 2001.
2. Harold G. Reading, *Sedimentary Environments: Processes, Facies and Stratigraphy*, Wiley-Blackwell; 3rd edition, 1996.
3. William F. Ruddiman, Earth's Climate: Past and future, W. H. Freeman & Co Ltd., 1st edition, 2001.

Supplementary Reading:

1. D. R. Prothero and Fred Schwab, *Sedimentary Geology*, W. H. Freeman; 2nd Edition, 2003.

ER 517 STRATIGRAPHY 3 Credits [3-0-0]

Principles of Stratigraphy; Stratigraphic Units; Stratigraphic Correlation; Geological Time Scale; Code of Stratigraphic nomenclature; Concept of Seismic and Sequence Stratigraphy; Biostratigraphy; Lithostratigraphy; Chemostratigraphy; Magnetostratigraphy; Chronostratigraphy; Precambrian stratigraphy of India; Stratigraphy of the Palaeozoic; Mesozoic and Cenozoic formations of India; Pleaogeographic and Paleoclimatic Condition.

Essential Reading:

1. M. S. Krishnan, *Geology of India and Burma,* C.B.S. Publ. and Distributors, Delhi, 1982.
2. S. M. Naqvi and J.J. W. Rogers, *Precambrian Geology of India,* Oxford University Press, 1987.

Supplementary Reading:

1. S. Boggs, *Principles of Sedimentology and Stratigraphy,* Prentice Hall, 2001.
2. Ravindra Kumar, *Fundamentals of Historical Geology and Stratigraphy of India*, New Age International, 1st edition, 1998.

ER 518 PALAEONTOLOGY 3 Credits [3-0-0]

Fossilization, Fossil record and geological time-scale. Morphology, time-ranges and evolutionary changes of invertebrates fossil groups–Brachiopoda, Mollusca, Trilobita, Echinoidea, Graptozoa. Evolutionary changes in mammals and reptiles in geological time. Siwalik vertebrate fauna and

Gondwana flora, evidence of life in Precambrian times, different microfossil groups and their distribution in India. Recent advancements in application of paleontology and micropaleontology.

Essential Reading:

1. Michael Foote, Arnold I. Miller, W. H. Freeman, *Principles of Paleontology*, 3rd Edition, 2006.
2. Michael J. Benton, David A. T. Harper, *Introduction to Paleobiology and the Fossil Record*, Wiley-Blackwell; 1st edition, 2009.

Supplementary Reading:

1. Bilal-Ul-Haq and Anne Boersoma, Introduction to Marine Micropaleontology, Elsevier Science, 1998.
2. D. R. Prothero, *Bringing Fossil to Life –An Introduction to Paleontology*, McGraw Hill, 2nd edition 2004.

ER 519 FUEL AND ECONOMIC GEOLOGY 4 Credits [3-1-0]

Magmatic, hydrothermal and surface processes of ore formation. Metallogeny and its relation to crustal evolution; Active ore-forming systems, methods of mineral deposit studies including ore microscopy, fluid inclusions and isotopic systematics; ores and metamorphism- cause and effect relationships. Geological setting, characteristics, and genesis of ferrous, base and noble metals. Origin, migration and entrapment of petroleum; properties of source and reservoir rocks; structural, stratigraphic and combination traps. Methods of petroleum exploration. Petroliferous basins of India. Origin of peat, lignite, bitumen and anthracite. Classification, rank and grading of coal; coal petrography, coal resources of India. Gas hydrates and coal bed methane. Nuclear and non-conventional energy resources

Mode of Occurrence and Distribution of various metals and non-metals. National Mineral Policy

Essential Reading:

1. Friedrich-Wilhelm Wellmer, Manfred Dalheimer and Markus Wagner, *Economic Evaluations in Exploration,* Springer; 2nd edition, 2010.
2. O. Rudawsky, *Mineral Economics: Development and Management of Natural Resources,* Elsevier Science, 1996.
3. Friedrich-Wilhelm Wellmer, Manfred Dalheimer and Markus Wagner, *Economic Evaluations in Exploration,* Springer; Softcover reprint of hardcover 2nd edition, 2010.
4. D. Chandra, R.M. Singh, M.P. Singh, *Textbook of Coal (Indian context)*, Tara Book Agency, Varanasi, 2000.
5. R.C. Selley, *Elements of Petroleum Geology*, Academic Press, USA, 1997
6. Holson, G.D. and Tiratso, E.N. (1985): Introduction of Petroleum Geology, Fulf Publishing, Houston, Texas.

Supplementary Reading:

1. A. Mookherjee, *Ore Genesis-A Holistic Approach,* Allied Publisher, 2000
2. A.M. Evans, *Ore Geology and Industrial Minerals,* Blackwell, 1993.
3. P.K. Banerjee and S. Ghosh, *Elements of Prospecting for Non-fuel Mineral deposits,* Allied Publ, 1997.

ER 520 HYDROGEOLOGY 3 Credits [3-0-0]

Hydrologic cycle and its importance to society, Tracing, Dating and Modeling of hydrologic cycle, Occurrence of groundwater, Aquifers, Darcy's Law, Porosity, Permeability, Storage Coefficient, Hydraulic conductivity, Transmissivity, Anisotropic Aquifers, Groundwater flow, Steady unidirectional flow, Steady radial flow, Unsteady radial flow, Soil-water processes-infiltration, evapotranspiration, Water quality, Groundwater prospecting, Application of remote sensing and GIS in hydrogeology, watershed- water quality models, acidification models, Groundwater provinces of India, Artificial recharge of groundwater, Saline water intrusion in Aquifers, Dispersion, Contaminant transport in vadose zone, groundwater contamination modeling. Impact of global warming on hydrology.

Essential Reading:

1. D. K. Todd, *Groundwater Hydrogeology*, John Wiley & Sons, 1995
2. O. M. Phillips, *Geological Fluid Dynamics Su-surface Flow and Reactions*, Cambridge University Press, 2009
3. K. R. Karanth, *Ground Water Assessment, Development and Management,* Tata Mc Graw Hill

Supplementary Reading:

4. C. A. J. Appelo, D. Postma, *Geochemistry, Groundwater and Pollution*, A. A. Balkema, 2005
5. F. H. Chapelle, F. Chapelle, *Ground-water Microbiology and Geochemistry*, John Wiley & Sons

ER 521 ENGINEERING GEOLOGY 3 Credits [3-0-0]

Role of engineering geology in civil construction and mining industry; Various stages of engineering geological investigations for civil engineering projects; Engineering properties of rocks and soil, rock discontinuities, physical characters of building stones, concrete and other aggregates; Influence of geological structures (fold, fault and joint) on Dam, Tunnel, Reservoir, Road and Bridge; Earthquake resistance design of building and influence of geological condition on foundation; Shoreline engineering geology; Improvement of sites for engineering projects; Mohs circle and failure mechanism, Basic concepts of rock excavation, Open and underground excavations, in-situ stress measurement techniques, Stress distribution in and around the openings. Rock mass rating. Instrumentation in Engineering Geology, Slope Stability, Mass movements – causes of landslides and their remedial measures.

Essential Reading:

1. F G Bell, *Engineering Geology,* Butterworth-Heinemann; 2nd edition, 2007.
2. Tony Waltham, *Foundations of Engineering Geology*, CRC Press; 3rd edition, 2009.
3. David George Price, Michaelde Freitas, *Engineering Geology: Principles and Practice,* Springer, 2010.

Supplementary Reading:

4. J. Jaeger, N. G. Cook and R. Zimmerman, *Fundamentals of Rock Mechanics,* Wiley-Blackwell; 4 edition, 2007.

ER 522 REMOTE SENSING & GIS 3 Credits [3-0-0]

Elements of photogrammetry, Stereoscopic Vision, Photo interpretation techniques, Definition and components of remote sensing, Electromagnetic waves and radiation principles, Multiconcept

remote sensing, interaction of EMW with various ground components: vegetation, water, snow, soil and minerals; Sensors and platforms, False color composite, Digital image processing: geometric and radiometric correction, image enhancement, band ratio, edge detection, filtering, principal component analysis, and image classification, Normalized difference vegetation index, Application of remote sensing in hydrology, mineral exploration, natural hazards like landslide, flood, and earthquake, Identification of surface feature, drainage pattern, structural patterns. Fundamentals of GIS, vector, raster and attribute data models, vector and raster data structure, spatial data input and editing, visualization and query of spatial data, spatial data transformations, spatial analysis, case studies of geological applications.

Essential Reading:

1. Thomas M. Lillesand, Ralph W. Kiefer, Jonathan W. Chipman*, "Remote Sensing and Image Interpretation",* John Wiley and Sons, 2004.
2. Rafael C. Gonzalez, Richard E. Woods, *"Digital Image Processing",* Addison-Wesley Publishing Company, 1992.
3. Shiv N Pandey *"Principle and Application of Photogeology"*, Wiley Eastern Limited, 1987.
4. Ravi P Gupta, *"Remote Sensing Geology"*, Springer, 2003.

Supplementary Reading:

1. S.A. Drury, "*A Guide to Remote Sensing: Interpreting Images of the Earth",* Oxford University Press, Oxford, 1990.
2. Brandt Tso, Paul M Mather "Classification Methods for Remotely Sensed Data", Taylor & Francis, 2001.

ER 523 GEOLOGY OF FUELS 3 Credits [3-0-0]

Coal Geology: Definition and origin of coal. Mode of occurrence of coal, Chemical analysis of coal, Coal Petrology – concept of 'Lithotype', 'Maceral' and 'Microlithotype'. Depositional environment, Classification of coal in terms of Rank, Grade and Type. Indian classification for coking and non-coking coals. International classifications, Elementary Idea about coal preparation, coal carbonization, coal gasification, coal hydrogenation, and coal combustion, Coal as a source rock in petroleum generation. Coal bed methane – a new energy resource. Elementary idea about generation of methane in coal beds, coal as a reservoir and coal bed methane exploration. 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. **Petroleum Geology:** Petroleum – its composition. Origin (Formation of source rocks-kerogen, organic maturation and thermal cracking of kerogen) and migration of petroleum. Reservoir rocks-porosity and permeability. Oil traps – structural, stratigraphic and combination traps. Oil field fluids – water, oil and gas. Methods of prospecting for oil and gas (geological modeling). Elementary knowledge of drilling and logging procedures. Oil shale. An outline of oil belts of the world. Onshore and offshore petroliferous basins of India. Geology of productive oilfields of India. **Mineralogy and geochemistry of radioactive minerals**: Instrumental techniques of detection and measurement of radioactivity. Radioactive methods for prospecting and assaying of mineral deposits. Distribution of radioactive minerals in India. Radioactive methods in petroleum exploration — well logging techniques. Nuclear waste disposal — geological constraints.

Essential Reading:

1. D. Chandra, R.M. Singh, M.P. Singh, *Textbook of Coal (Indian context)*, Tara Book Agency, Varanasi, 2000.
2. R.C. Selley, *Elements of Petroleum Geology*, Academic Press, USA, 1997

3. Holson, G.D. and Tiratso, E.N. (1985): Introduction of Petroleum Geology, Fulf Publishing, Houston, Texas.
4. North, F.K. (1985): Petroleum Geology, Allen Unwin.
5. Selley, R.C. (1998): Elements of Petroleum Geology, Academic Press.

Supplementary Reading:

1. K. Bjørlykke, *Petroleum Geoscience: From Sedimentary Environments to Rock Physics*, Springer, 2010
2. A.C. Scott, *Coal and Coal-bearing strata: Recent Advances*, The geological Society of London, Publication no. 32, Blackwell scientific Publications, 1987.

ER 524 ENVIRONMENT GEOLOGY 3 Credits [3-0-0]

Fundamental concepts and principles; Natural hazards — preventive/precautionary measures — floods, landslides, earthquakes, river and coastal erosion; Environmental impact of resource exploitation, river-valley projects, disposal of industrial and radio-active waste, excess withdrawal of ground water, use of fertilizers, dumping of ores, mine waste and fly-ash; Environment of water, sediment and soil; Organic and inorganic contamination of ground water and their remedial measures; Soil degradation and remedial measures. Environment protection — legislative measures in India; Biogeochemical cycle of carbon and nitrogen.

Essential Reading:

1. Carla Montgomery, *Environmental Geology,* McGraw-Hill Science/Engineering/Math; 9th edition, 2010.
2. Edward A. Keller, *Environmental Geology,* Prentice Hall; 9th edition, 2010.

Supplementary Reading:

1. Daniel B. Botkin, *Environmental Science Earth as a Living Planet,* Wiley; 8th edition. 2009.

ER 525 ISOTOPE GEOLOGY 3 Credits [3-0-0]

Introduction to isotopes and their properties, Decay mechanisms of radioactive atoms, Equations of Radioactive Decay and Radiogenic Growth, Geochronology using radioactive isotopes, Fission track Dating, Analytical methods in Thermal Ionization Mass Spectrometry, Isotope Geochemistry of the Earth's Mantle and crust, Isotopic evidence regarding the formation of the Earth and Tectonics setting, Stable Isotope Theory, Kinetic and equilibrium isotope fractionation, Analytical methods in Stable isotope ratio mass spectrometry, Applications of stable isotopes in hydrology, environment and climate, archaeology and palaeontology.

Essential Reading:

1. Claude J. Allègre, *Isotope Geology,* Cambridge University Press, 2008.
2. Gunter Faure, Teresa M. Mensing, *Isotopes: Principles and Applications,* Wiley; 3rd edition, 2004.
3. Zachary Sharp, *Principles of Stable Isotope Geochemistry,* Prentice Hall; 1st edition, 2006.

ER 526 GEOPHYSICAL METHODS 3 Credits [3-0-0]

Fundamental concepts of Geophysics;, Principle, interpretation and instrumentation of various geophysical methods - Gravity, Magnetic, Seismic, Electromagnetic; Electrical and Radioactive survey; Introduction to well logging methodology and various logging techniques.

Essential Reading:

1. Milton B. Dobrin and Carl H. Savit, *Introduction to Geophysical Prospecting,* 4th Edition, Mcgraw-Hill College; 4 Sub edition, 1998.
2. Philip Kearey, Michael Brooks, Ian Hill, *An Introduction to Geophysical Exploration (2002),* Wiley-Blackwell; 3 edition, 2003.
3. James K. Hallenburg, *Standard Methods of Geophysical Formation Evaluation,* CRC Press; 1 edition, 1997.

Supplementary Reading:

1. William Lowrie, *Fundamental of Geophysics,* Cambridge University Press, 2nd edition, 2007.

ER 527 GEOSTATISTICS 3 Credits [3-0-0]

Definition of Resource and reserve, traditional resource estimation techniques, introduction to geostatistics, Concept of random function and probabilistic distribution, uni-variate and bi-variate distribution parameters, covariance function and variograms, variograms modeling and fitting theoretical variogram functions, geostatistical interpolation using ordinary kriging, simple kriging; concept of block Kriging, variance volume relationships, change of support, correcting for support effect, dispersion variance, non-parametric geostatistical models: indicator kriging, disjunctive kriging, log-normal kriging, universal kriging, grade tonnage curve.

Essential Reading:

1. E. H. Isaaks and R. M. Srivastava, *An Introduction to Applied Geostatistics,* Oxford University Press, USA, 1990.
2. P. Goovaerts, *Geostatistics for Natural Resources Evaluation,* Oxford University Press, 1997.

Supplementary Reading:

3. A. J. Sinclair and G. H. Blackwell, *Applied Mineral Inventory Estimation,* Cambridge University publication, 2002.

ER 528 INTRODUCTION TO ATMOSPHERE AND OCEAN SCIENCE 3 Credits [3-0-0]

Structure and composition of the atmosphere; Thermodynamics of dry and moist air; Formation of Cloud droplets and Precipitation; Radiation budget; Cyclone, Anticyclone, Hurricane and Tornado; Atmospheric modeling; Atmospheric Chemistry, Air Pollution, Fog-haze formation, Aerosol-Cloud interaction and chemistry, Ozone layer depletion, Characteristics of Ocean Basins, Properties of Sea water; Air-Sea Interaction; Ocean Circulation; Waves and Tides; Marine Biogeochemistry.

Essential Reading:

1. E. Aguado, J. E. Burt, *Understanding Weathering and Climate,* Prentice Hall, 1999.
2. C. Neil, *The Atmosphere and Ocean: A Physical Introduction (Advancing Weather and Climate Science),* Wiley; 3 edition, 2011.

3. Maarten H. P. Ambaum; *Thermal Physics of the Atmosphere (Advancing Weather and Climate Science),* Wiley; 1 edition, 2010.

Supplementary Reading:

1. H. V. Thurman, A. P. Trujillo; *Essentials of Oceanography,* Prentice Hall, 1999.

ER 529 TECTONIC GEODESY: CRUSTAL DEFORMATION & ACTIVE TECTONICS 3 Credits [3-0-0]

Historical background of Tectonic Geodesy, definition and scope of Geodesy, Introduction to space-based techniques, basic principle of GNSS, network designing, site establishment, data acquisition, data processing, modeling of geodetic data (Okada, COULOMB, ANSYS, SSPX, RELAX etc), geodynamic applications (earthquake and volcano related deformation process), different case studies, problem sets, discussion/feedbacks and project presentation.

Essential Reading:

1. Paul Segall, *Earthquake and Volcano Deformation,* Cambridge University press, 1st edition, 2012.

2. Gunter Seeber, *Satellite Geodesy,* 2nd edition.

Supplementary Reading:

1. J. Jaeger, N. G. Cook and R. Zimmerman, *Fundamentals of Rock Mechanics,* Wiley-Blackwell; 4th edition, 2007.

ER 530 RHEOLOGY OF THE EARTH 3 Credits [3-0-0]

Continuum mechanics and Rheology, Stress, deformation and strain, Elasticity, Flow, strain rate and viscosity, Strength, fracture and Plasticity, Continuum approach of Earth: Short term scale vs Long term scale process of the Earth, Internal composition of Earth and its rheological variations, Earthquake cycle, Post-seismic deformation, Earthquake and Volcano interactions.

Essential Reading:

1. Deformation of Earth Materials, 2008, Shun-Ichiro Karato, Cambridge University press.

2. The Rheology of Earth, 1995, G. Ranalli, Cambridge University press.

Supplementary Reading:

1. J. Jaeger, N. G. Cook and R. Zimmerman, *Fundamentals of Rock Mechanics,* Wiley-Blackwell; 4th edition, 2007.

ER 531 EARTHQUAKE AND VOLCANO DEFORMATION 3 Credits [3-0-0]

Concept of stress and strain, Rheology, Earthquake cycle, Post-seismic deformation, Earthquake and Volcano interactions. Dislocation models of Strike-Slip faults, Dip-Slip faults, Crack models of faults, Elastic heterogeneity, Postseismic Relaxation, Volcano deformation, Topography and earth Curvature, Gravitational effect, Poroelastic effects, Fault Frictions, Interseismic Deformationa and Plate Boundary Cycle Models, Slow-slip events, Global case studies.

Essential Reading:

1. Earthquake and Volcano deformation, 2012, Paul Segall, Princeton press.
2. Introduction to seismology, 2010, Peter M. Shearer, Cambridge University press.

Supplementary Reading:

1. Gunter Seeber, *Satellite Geodesy,* 2nd edition.
2. J. Jaeger, N. G. Cook and R. Zimmerman, *Fundamentals of Rock Mechanics,* Wiley-Blackwell; 4th edition, 2007.

ER 532 WEATHER AND CLIMATE SYSTEMS 3 Credits [3-0-0]

Simple wave motions, Difference between tropics and extra tropics, Extra-tropical weather systems, Tropical weather, Tropical and extra-tropical cyclone, Clouds and severe weather, Mountain weather, Polar weather, thunderstorms, hail and tornadoes; Haze, Mist, Smog and Fog; Local wind systems; The major wind systems; Air masses; Fronts and frontogenesis; Over view of the severe convective storms, Cyclonic systems, tornadoes and tornadic storms; Tropical disturbances, storms and hurricanes; General circulation, Introduction to physical climate, Seasonality on Earth, General climate of India, Summer and winter monsoon, Asian monsoon system, An overview of Global climate, Climate variability, An introductory idea of climate change and global warming, Regional climate change, Impact of climate change

Essential Readings:

1. Applied Atmospheric Dynamics – A. H. Lynch and J. J. Cassano, John Wiley and Sons Ltd
2. Climate Change and Climate Modeling - J. David Neelin, Cambridge University Press

Supplementary Readings

1. Climate in Asia and the Pacific- Advances in Global Change Research, Vol. 56 Manton, Michael, Stevenson, Linda Anne (Eds.), 2014, XVIII, Springer Publishers
2. Tropical Meteorology - Krishnamurti, T.N., Stefanova, Lydia, Misra, Vasubandhu 2013, XV, Springer Publishers

ER 601 THEORETICAL METEOROLOGY 3 Credits [3-0-0]

Introduction to Earth and atmosphere; The Equation of State, The Principles of Thermodynamics, The thermodynamics of water vapour and moist air, Thermodynamic Diagrams, Hydrostatic Equilibrium, Hydrostatic Stability and Convection, The fundamental physics of radiation, Solar and terrestrial radiation, Application of Radiation in the Earth-Atmosphere System

The equation of motion on a rotating earth; Horizontal motion under balanced forces; Kinematics of fluid flow; The mechanism and influence of pressure changes; Surface discontinuity; Circulation, Vorticity and Divergence; The fundamental Equations using pressure as an independent coordinate; Viscosity and Turbulence; Energy and Stability relationships; Numerical weather prediction; The general circulation

Essential Reading:

1. Hess S. L. (1959): Introduction to Theoretical Meteorology, Krieger Publishing Company Malabar, Florida
2. Lynch A. H. and and J. J. Cassano (2005): Applied Atmospheric Dynamics, John Wiley and Sons Ltd

Supplementary Reading:

1. Sverre Petterssen (1958): Introduction to meteorology, Second Edition, McGraw Hill Book Company
2. Roland Stull (2000): Meteorology (for scientists and engineers), Second edition, Brooks/Cole Thomson Learning.
3. Haltiner G. J. and F.L.Martin (1957): Dynamical and Physical Meteorology, McGraw-Hill Publcations,
4. Houghton H. G. (1985): Physical Meteorology, MIT Press
5. Iribarne J. V. and W.L.Godson (1981): Atmospheric Thermodynamics, Springer

ER 602 APPLIED ATMOSPHERIC DYNAMICS 3 Credits [3-0-0]

Introduction to wind systems in atmosphere; Mathematical methods in fluid dynamics; Properties of fluids; Fundamental forces; Scale analysis; Simple steady motion; Circulation and vorticity; Simple wave motions; Tropical and extra tropical weather systems;

Boundary layers; Clouds and severe weather; Tropical weather; Mountain weather; Polar weather; Introduction to general circulation

Essential Reading:

1. Lynch A. H. and and J. J. Cassano (2005): Applied Atmospheric Dynamics, John Wiley and Sons Ltd
2. Holton J. R. (2004): An introduction to Dynamic Meteorology, 4th Edition, Elsevier, Burlington, MA.

Supplementary Reading:

1. Hess S. L. (1959): Introduction to Theoretical Meteorology, Krieger Publishing Company Malabar, Florida
2. Roland Stull (2000): Meteorology (for scientists and engineers), Second edition, Brooks/Cole Thomson Learning.
3. C. Donald Ahrens (1988): Meteorology Today (An introduction to weather, climate and environment), Third Edition, West Publishing Company.

ER 603 INTRODUCTION TO CLIMATE SCIENCE 3 Credits [3-0-0]

Climate science for today's world; Climate and the atmosphere; Monitoring Earth's climate system; Planetary energy budget in Earth's climate system; Thermal response of the climate system; Water in Earth's climate system; Global atmospheric circulation; Atmospheric circulation and regional climates; Climate and air-sea interactions; The climate record and paleoclimates; Instrument based climate record and climatology of severe weather; Climate classification; Climates dominated by equatorial and tropical air masses; Climates dominated by tropical and polar air masses; Climates dominated by polar and arctic air masses; High-land and ocean climates; Modifying weather and

climate; Climate Change; Natural causes of climate change; Anthropogenic climate change and the future; Responding to climate change; Climate change and public policy

Essential Reading:

1. Moran J. M. (2010): Climate Studies (Introduction to climate science), American Meteorological Society, Boston, MA, USA
2. Critchfield H. J. (1992): General Climatology, 4th Edition, Prentice Hall of India Pvt. Ltd, New Delhi, India.

Supplementary Reading:

1. Miler A. A. (2001): Climatology, Subhi publication, New Delhi, India.
2. Singh C. (2007): Global warming and Climatology, Akansha publishing house, New Delhi, India
3. Awasthi A. (2012): Climatology, Aph publishing corporation, India
4. Lal D. S. (2011): Climatology, Shradha pustak bhawan, Allahabad, India
5. Roland Stull (2000): Meteorology (for scientists and engineers), Second edition, Brooks/Cole Thomson Learning.
6. C. Donald Ahrens (1988): Meteorology Today (An introduction to weather, climate and environment), Third Edition, West Publishing Company.

ER 604 BOUNDARY LAYER METEOROLOGY 3 Credits [3-0-0]

Introduction: definitions and background, variables, wind and flow, turbulent transports; Taylor's hypothesis and observing techniques, boundary layer depth and structure

Mathematical and conceptual tools: Turbulence and its spectrum; spectral gap; mean and turbulent parts; basic statistical methods; rules of averaging; turbulent kinetic energy; kinematic flux, eddy flux; stresses.

Governing equations for turbulent flow: methodology, basic equations, simplifications and approximations, equations for mean variables in a turbulent flow, prognostic equations for turbulent fluxes and variables, TKE budget and stability; turbulent closure techniques.
Mixed layer theory: mixing and entropy; governing equations, model behaviour, surface fluxes and entrainment.

Stable boundary layer: Understanding stable boundary layer concepts and related applications over land, arctic stable boundary layer, modeling and evolution of stable boundary layer over land surface, diurnal cycles, possible role of small scale terrain drag on stable boundary layers over land, land-surface boundary layer characteristics in calm and windy conditions

Cloud-topped boundary layers: moisture variables; radiative processes, observed structure; governing equations, entrainment. Trade wind boundary layer: mean structure and fluxes; moist convective processes; sub-cloud layer interactions; strato-cumulus to trade cumulus transitions, monsoon trough boundary layer

Deep convection and Marine boundary layer: controls on deep convection; MABL modification by downdrafts; boundary layer recovery; Thermal internal boundary layer concepts and modeling

Geographic effects on boundary layer: Geographically generated local winds and modified flow, urban boundary layer characteristics, urban heat island, urban modification of flow, urban weather and mesoscale weather

Atmospheric boundary layer modeling and parameterizations

Essential Reading:

1. Roland B. Stull (1991): An introduction to boundary layer meteorology, Kluwer academic publishers.
2. Lambert M. Surhone, Mariam T. Tennoe, Susan F. Henssonow (Edited) (2010): Planetary boundary layer, Betascript publishing.

Supplementary Reading:

1. James R. Holton (2012): An introduction to dynamic meteorology, 5th Edition, Academic Press
2. Steeneveld G. J. (2007): Understanding and prediction of stable atmospheric boundary layers over land, ISBN 978-90-8504-716-2
3. Narasimha R., D. R. Sikka and A. Prabhu (Edited) (1997): The monsoon trough boundary, Indian Academy of Sciences, Banglore, India.
4. J. Panda and M. Sharan (2012): Some atmospheric boundary layer characteristics over north India, Lambert Academic Publishing, Germany.
5. Hamza Varikoden and C. A. Babu (2011): Atmospheric boundary layer dynamics, Lambert Academic Publishing, Germany.

ER 605 INTRODUCTION TO MICROSCALE AND MESOSCALE METEOROLOGY 3 Credits [3-0-0]

Introduction to atmosphere; Instruments and observations; Clouds and precipitation; Condensation and precipitation processes; Heat and temperature changes; Radiation and exchange of heat; Showers, thunderstorms, hail and tornadoes; Haze, Mist, Smog and Fog; The laws of motion applied to atmospheric science; Local wind systems; The major wind systems; Air masses; Fronts and frontogenesis; Over view of the severe convective storms, Mesoscale processes and severe convection; Mesoscale convective systems; Cyclonic systems, tornadoes and tornadic storms; Cloud and precipitation in mesoscale systems; Tropical disturbances, storms and hurricanes; Temperature regimes; Precipitation regimes; World climates; Introduction to weather forecasting, observations and analysis.

Essential Reading:

1. Sverre Petterssen (1958): Introduction to meteorology, Second Edition, McGraw Hill Book Company
2. Roland Stull (2000): Meteorology (for scientists and engineers), Second edition, Brooks/Cole Thomson Learning.
3. C. Donald Ahrens (1988): Meteorology Today (An introduction to weather, climate and environment), Third Edition, West Publishing Company.
4. Lynch A. H. and and J. J. Cassano (2005): Applied Atmospheric Dynamics, John Wiley and Sons Ltd

Supplementary Reading:

1. Charles A. Doswell III (Edited) (2001): Severe convective storms, American Meteorological Society.
2. David Brunt (1928): Meteorology, Oxford University Press
3. Hess S. L. (1959): Introduction to Theoretical Meteorology, Krieger Publishing Company Malabar, Florida
4. Houghton H. G. (1985): Physical Meteorology, MIT Press
6. Iribarne J. V. and W.L.Godson (1981): Atmospheric Thermodynamics, Springer

ER 606 MESOSCALE METEOROLOGY AND MODELING 3 Credits [3-0-0]

Circulation systems related to orography, valley winds, energy budgets, cloudiness, precipitation, evaporation, fog, lightening, snow avalanches and valley air pollution; general
properties of mountain perturbations, adiabatic meso-scale perturbations in a straight atmospheric flow, adiabatic synoptic scale perturbations, dissipation of mechanical energy, mountain drag, modeling aspects of mountain waves, mountain generated momentum fluxes, theory of linear gravity waves, orographic gravity-wave drag, its parameterization and influence in general circulation models.

Modeling mesoscale processes: Basic set of equations used in mesoscale models; Simplifying basic equations; Averaging the conservation relations; Physical and analytic modeling; Coordinate transformations; Parameterizing subgridscale fluxes; Averaged radiation flux divergence; Parameterization of moist processes; Methods of solution; Boundary and initial conditions; Model evaluation; Examples of mesoscale models

Essential Reading:

1. James R. Holton (2012): An introduction to dynamic meteorology, 5th Edition, Academic Press
2. Roger A. Pielke Sr (2002): Mesoscale meteorological modeling, Second Edition, Academic Press.
3. Lynch A. H. and and J. J. Cassano (2005): Applied Atmospheric Dynamics, John Wiley and Sons Ltd

Supplementary Reading:

1. Roland Stull (2000): Meteorology (for scientists and engineers), Second edition, Brooks/Cole Thomson Learning.
2. C. Donald Ahrens (1988): Meteorology Today (An introduction to weather, climate and environment), Third Edition, West Publishing Company.

ER 607 APPLICATION OF TECTONIC GEODESY 3 Credits [3-0-0]

Historical background of Tectonic Geodesy, definition and scope of Geodesy, Introduction to space-based techniques, basic principle of GNSS, network designing, site establishment, data acquisition, data processing, modeling of geodetic data (Okada, COULOMB, ANSYS, SSPX, RELAX etc), geodynamic applications (earthquake and volcano related deformation process), different case studies, problem sets, discussion/feedbacks and project presentation.

Essential Reading:

4. Paul Segall, *Earthquake and Volcano Deformation,* Cambridge University press, 1st edition, 2012.

5. Gunter Seeber, *Satellite Geodesy,* 2nd edition.

Supplementary Reading:

2. J. Jaeger, N. G. Cook and R. Zimmerman, *Fundamentals of Rock Mechanics,* Wiley-Blackwell; 4th edition, 2007.

ER 608 ROCK WATER INTERACTION 3 Credits [3-0-0]

Chemical equilibrium; Aqueous solution; Introduction to thermodynamics; Rock Weathering; Soil Formation; Elemental Mobility; Clay Minerals; Solution-Mineral Equilibrium – Silicate and Carbonate; Surface Chemistry – Sorption and Desorption processes; Oxidation Reduction reactions; Reaction kinetics; Interaction of rock with geothermal fluid; Mobility and bioavailability of metals; Acid mine drainage

Essential Reading:

3. K. B. Krauskopf and D. K. Bird, *Introduction to Geochemistry,* McGraw-Hill, 1995.
4. C.A.J. Appelo, D. Postma, *Geochemistry, Groundwater and Pollution*, Taylor & Francis; 2nd edition, 2005.
5. B. C. Raymahashay, *Geochemistry for Hydrologist,* Applied Publisher, 1998.

Supplementary Reading:

3. J. V. Walter, *Essentials of Geochemistry*, Jones and Bartlett, 2010
4. J. I. Drever, *The Geochemistry of Natural Waters*, Prentice Hall, 1997

ER 609 GEOCHRONOLOGY 3 Credits [3-0-0]

Fundamentals of radioactive decay and growth; geochronology and thermochronology; Diffusion of elements in minerals and heat in the Earth; Trace element behaviour; Differentiation and recycling processes in the Earth and other solar system objects; Dendrochronology; Radiocarbon dating; Details of various geochronometers: Rb-Sr, Re-Os, Sm-Nd, Lu-Hf, K-Ar, Ar-Ar, U-Th, U-Pb; Thermo-luminescence (TL); relative age constraints.

Essential Readings:

1. G. Faure, Principles of isotope geology, Wiley 2nd edition, 608 pp., 1986.
2. A. P. Dickin, Radiogenic Isotope Geology, Cambridge Publishers, 2nd edition, 492 pp., 2005.

Supplementary Reading:

1. C. J. Allegre, Isotope Geology, Cambridge Publishers, 1st edition, 512 pp., 2008.

ER 610 APPLIED ISOTOPE GEOLOGY 3 Credits [3-0-0]

Zero-point energy; Mass dependent and independent isotope fractionation; Application of isotopes in planetary sciences; Isotopes as tracers of geological processes: Evolution of mantle and continents; Provenance of dusts; Sources, transport and deposition of sediments; Erosion rates; Water exchange and ocean mixing time; Sub-marine groundwater discharge; Paleoclimate; Paleoceanography; Anthropogenic processes.

Essential Readings:

1. Radiogenic Isotope Geology, Cambridge Publishers, 2nd edition, 492 pp., 2005.
2. C. M. Johnson, B. L. Beard, F. Albarede, Geochemistry of non-traditional stable isotopes, Reviews in Minerology and geochemistry, Vol. 55, 454 pp., 2004.

Supplementary Reading:

1. R. Criss, Principles of stable isotope distribution, Oxford University Press, 1st edition, 254 pp., 1999.

ER 611 INSTRUMENTATION FOR EARTH SCIENTISTS 3 Credits [3-0-0]

Basic principles of particle analyzer, Optical spectrometry, Neutron activation, Ion Chromatography, XRF, XRD, CNS analyzer, Coulometer, AAS, AES, Q-ICPMS, TIMS, Stable isotope mass spectrometer, MC-ICPMS. Data accuracy and precision, International reference materials, Sample preparation and analysis. Introduction to space-based techniques, basic principle of GNSS, seismogram, gravimeter, electrical, well loging instruments etc.

Essential Readings:

1. P.J. Potts, A handbook of silicate rock analysis, Springer, 622 pp., 1992

Supplementary Reading:

1. F. Vanhaecke, P. Degryse, Isotopic analysis: Fundamentals and applications using ICP-MS, Wiley-VCH, 1st edition, 529 pp., 2012.

ER 612 PETROLEUM GEOLOGY 3 Credits [3-0-0]

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.

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).

Oilfields of India

Essential Readings:

1. Holson, G.D. and Tiratso, E.N. (1985): Introduction of Petroleum Geology, Fulf Publishing, Houston, Texas.
2. North, F.K. (1985): Petroleum Geology, Allen Unwin.
3. Selley, R.C. (1998): Elements of Petroleum Geology, Academic Press.

Supplementary Reading:

1. Barker, C. (1996): Thermal Modeling of Petroleum Generation, Elsevier Science, Netherlands.
2. Jahn, F., Cook, M. and Graham, M. (1998): Hydrocarbon exploration and production, Eslevier Science.
3. Tissot, B.P. and Welte, D.H. (1984): Petroleum Formation and Occurrence, Springer–Verlag

ER 613 COAL GEOLOGY 3 Credits [3-0-0]

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).

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.

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.

Coal Bed Methane (CBM) – Non Conventional clean energy resources.; Elementary idea about generation of methane in coal beds; coal as a reservoir and coal bed methane /Coal Mine Methane Shale gas etc exploration

Essential Readings:

1. Chandra, D., Singh, R.M. Singh, M.P. (2000): Textbook of Coal (Indian context), Tara Book Agency, Varanasi.
2. Scott, A.C. (1987): Coal and Coal-bearing strata: Recent Advances, Blackwell Scientific Publications.
3. Thomas, Larry (2002): Coal Geology, John Wiley and Sons Ltd., England.

Supplementary Reading:

1. 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.

ER 614 GEOSTATISTICS 3 Credits [3-0-0]

Frequency distribution; Central Limit theorem; Fundamentals of probability and probability distribution function; Conditional probability; hypothesis testing; linear regression; principal component analysis; cluster analysis; uni-variate and bi-variate distribution parameters, variance and covariance function; variograms; geostatistical interpolation using ordinary kriging, simple kriging; concept of block Kriging, variance volume relationships, change of support, correcting for support effect, dispersion variance, non-parametric geostatistical models: indicator kriging, disjunctive kriging, log-normal kriging, universal kriging, grade tonnage curve.

Essential Reading:

4. E. H. Isaaks and R. M. Srivastava, *An Introduction to Applied Geostatistics*, Oxford University Press, USA, 1990.
5. P. Goovaerts, *Geostatistics for Natural Resources Evaluation*, Oxford University Press, 1997.

Supplementary Reading:

1. A. J. Sinclair and G. H. Blackwell, *Applied Mineral Inventory Estimation*, Cambridge University publication, 2002.

2. D. D. Sharma, *Geostatistics with Applications in Earth Sciences*, Capital Publishing Company, 2009

ER 615 APPLIED HYDROGEOLOGY 3 Credits [3-0-0]

Hydrologic cycle; Tracing, Dating and Modeling of hydrologic cycle; Occurrence of groundwater; Aquifers; Darcy's Law; Properties of the Aquifers; Anisotropic Aquifers; Groundwater flow, Steady unidirectional flow, Steady radial flow, Unsteady radial flow, Ground water quality, Saline water intrusion in Aquifers, Dispersion, Contaminant transport in vadose zone, groundwater contamination modeling. Groundwater prospecting, Ground water recharge

Essential Reading:

1. D. K. Todd, *Groundwater Hydrogeology*, John Wiley & Sons, 1995
2. K. R. Karanth, *Ground Water Assessment, Development and Management,* Tata Mc Graw Hill,
3. C. A. J. Appelo, D. Postma, *Geochemistry, Groundwater and Pollution*, A. A. Balkema, 2005

Supplementary Reading:

1. O. M. Phillips, *Geological Fluid Dynamics Su-surface Flow and Reactions*, Cambridge University Press, 2009
2. F. H. Chapelle, F. Chapelle, *Ground-water Microbiology and Geochemistry*, John Wiley & Sons

ER 616 SATELLITE REMOTE SENSING FOR GEO-RESOURCE EVALUATION 3 Credits [3-0-0]

Electromagnetic Radiation – Characteristics and Remote Sensing Regions and bands; Aerial photos – types, scale, resolution; properties of aerial photos, stereoscopic parallax, Relief displacement; General Orbital characteristics of remote sensing satellites; General sensor characteristics of remote sensing satellites; Spectra of common natural objects – soil, rock, water and vegetation. Thermal remote sensing, Microwave remote sensing, Characteristics of remote sensing data; Preprocessing of remotely sensed data; Enhancements, Classification, Elements of photo and imagery interpretation, Principles and Components of GIS, Application of remote sensing and GIS in engineering geology, and subsidence, hydrogeology, mineral exploration, mine reclamation, mine fire detection, environmental impact assessment, mapping surface moisture and rock types.

Essential Reading:

1. T.M. Lillesand, R.W. Kiefer, J.W. Chipman*, Remote Sensing and Image Interpretation,* John Wiley and Sons, 2004.
2. R.C. Gonzalez, R.E. Woods, *Digital Image Processing,* Addison-Wesley Publishing Company, 1992.

Supplementary Reading:

1. I. H. Woodhouse, *Introduction to Microwave Remote Sensing*, CRC Press, 2005
2. S. N Pandey, *Principle and Application of Photogeology*, Wiley Eastern Limited, 1987.
3. R.P Gupta, *Remote Sensing Geology*, Springer, 2003.
4. S.A. Drury, *A Guide to Remote Sensing: Interpreting Images of the Earth*, Oxford University Press, Oxford, 1990.
5. B.Tso, P.M Mather, *Classification Methods for Remotely Sensed Data*, Taylor & Francis, 2001

DEPARTMENT OF LIFE SCIENCE

DETAILED SYLLABI OF COURSES

Sub. Code	Subject	L-T-P	Credits
LS 401	Microbiology	3-1-0	4
LS 402	Biochemistry	3-1-0	4
LS 403	Immunology	3-1-0	4
LS 404	Molecular Biology and Biotechnology	3-1-0	4
LS 405	Cell biology	3-1-0	4
LS 406	Fundamentals of Cell Biology	3-0-0	3
LS 410	Food Science	3-1-0	4
LS 411	Biophysics	3-1-0	4
LS 412	Advanced Microbial genetics	3-1-0	4
LS 413	Basic Biophysics	3-0-0	3
LS 414	Microbial Genetics	3-0-0	3
LS 420	Applied Bioinformatics	3-1-0	4
LS 421	Radiation Biology	3-1-0	4
LS 422	Cell – Cell Signaling	3-1-0	4
LS 423	Advanced Techniques	3-1-0	4
LS 424	Genomics & Proteomics	3-1-0	4
LS 425	Introduction to Bioinformatics	3-0-0	3
LS 427	Advanced Techniques	3-0-0	3
LS 435	Microbial diversity and Extremophiles	3-0-0	3
LS 440	Physical Sciences and Instrumentation	3-1-0	4
LS 471	Microbiology Laboratory	0-0-3	2
LS 472	Biochemistry Laboratory	0-0-3	2
LS 473	Biotechnology Laboratory	0-0-3	2
LS 474	Molecular Biology Laboratory	0-0-3	2
LS 475	Immunology Laboratory	0-0-3	2
LS 502	Advances in Structural Biology	3-1-0	4
LS 503	Recombinant DNA Technology	3-0-0	3
LS 504	Environmental Sciences and Biostatistics	3-1-0	4
LS 505	Food Processing technology	3-1-0	4
LS 507	Structural Biology	3-0-0	3
LS 509	Introduction to Proteomics	3-0-0	3
LS 511	Genetics	3-1-0	4
LS 512	Developmental Biology	3-1-0	4
LS 513	Enzymology & Metabolism	3-1-0	4
LS 514	Fundamental of Genetics	3-0-0	3
LS 530	Aquatic biology and marine biotechnology	3-1-0	4
LS 531	Epigenetics	3-1-0	4
LS 532	Molecular Medicine	3-1-0	4
LS 533	Marine Biotechnology	3-0-0	3
LS 534	Introduction to Epigenetics	3-0-0	3
LS 535	Basics in Molecular medicine	3-0-0	3
LS 536	RNAi, Stem cells and Oncogenomics	3-1-0	4
LS 537	Processing of Food Commodities	3-0-0	3
LS 538	Man and Microbes	3-0-0	3
LS 539	Stem Cell and Regenerative Medicine	3-0-0	3
LS 540	Research Methodology	3-0-0	3

LS 542	Basic Biotechnology	3-0-0	3
LS 571	Ecology and Environmental Science Laboratory	0-0-3	2
LS 575	Applied Bioinformatics Laboratory	0-0-3	2
LS 581	Cancer Biology	3-1-0	4
LS 582	Special Topics in Life Science – II	3-1-0	4
LS 583	Special Topics in Modern Biology – I	3-1-0	4
LS 584	Special Topics in Modern Biology – II	3-1-0	4
LS 585	Special Topics in Applied Life Science – I	3-1-0	4
LS 586	Special Topics in Applied Life Science – II	3-1-0	4
LS 591	Research Project – I	0-0-6	4
LS 592	Research Project – II	0-0-9	6
LS 593	Seminar & Technical writing – I	0-0-3	2
LS 594	Seminar & Technical writing – II	0-0-3	2
LS 595	Short-term Industrial/Research Experience (SIRE)	0-0-3	2
LS 596	Comprehensive Viva – Voce	0-0-0	2

LS 401 MICROBIOLOGY 4 credits [3-1-0]

Unit- 1: Introduction to microbiology

Introduction to Microbiology; Discovery of the microbial world, controversy over spontaneous generation, Koch's postulate, development of pure culture methods. Microbial Taxonomy- low G+C gram positive bacteria; high G+C gram positive bacteria. Yeast and filamentous fungi, Viruses. Classification of prokaryotes and bacterial taxonomy: short description of different groups under Archaebacteria (Extremophiles: Thermophiles, Halophiles and Acidophiles), under Eubacteria (Myxobacteria, Mycoplasma, Actinomycetes, Rickettsias and Chlamydiae) and auxotrophs including Cyanobacteria.

Unit- 2: Microbial nutrition

Cultivation of bacteria – nutritional requirements of micro organism, physical requirements, different types of media & their preparations. Isolation of pure cultures, maintenance and preservation of the pure cultures. Culture characteristics – Bacterial growth – Growth curve, batch and continuous cultures diauxic and synchronous growth. Enumeration of cells by direct and indirect methods.

Unit- 3: Control of microorganisms

Concept of sterilization and disinfection. Physical and chemical methods of control. Chemotherapeutics – mode of action of antibiotics, Penicillin, ampicillin, sulfonamide, vancomycin, streptomycine, tetracycline, chloramphenicol, antifungals, antiviral etc. Antibiotic resistance.

Unit- 4: Microbial genetics

The basic principles of microbial DNA, replication, transcription and translation. Mutation and DNA repair- Types of mutations, molecular basis of mutation, spontaneous mutation, reverse mutations & suppressor mutations, Mutagens, mechanisms of DNA repair (Photo reactivation, Nucleotide excision repair, Mismatch correction, SOS repair). Extra chromosomal DNA structures. Different types of plasmids: F plasmids, R plasmids and Col plasmids. Importance of plasmids for bacterial survival and antibiotic resistance. Transposons. Genetic recombination and mechanisms of recombination processes. Horizontal gene transfer in bacteria: Transformation, conjugation and transduction. Lytic and lysogenic life cycles of bacteriophages. Operon systems for gene expressions in prokaryotes- *lac* and *trp* operon.

Unit-5: Recombinant DNA technology

Definition, importance and applications of recombinant DNA technology. Different kinds of vectors used in recombinant DNA technology [Plasmids, bacteriophages (Lambda and M13), phagemids, cosmids, artificial chromosomes (YAC, BAC)]. Restriction endonucleases, methyltransferase, ligase, polymerase, kinase, phosphatase, nuclease, transferase, reverse transcriptase, linkers, adapters-design of cloning strategy and stepwise experimental procedure. Polymerase chain reactions (PCR) and site directed mutagenesis. Restriction mapping. DNA sequencing (Maxam Gilbert, Sanger's and

automated). Construction of cDNA and genomic libraries. DNA fingerprinting and its application in forensic science.

Unit- 5: Medical microbiology

Normal microflora of host –normal micro flora of skin, oral cavity, gastrointestinal tract, Respiratory tract; host-parasite relationship, entry of pathogens into the host, types of toxins (Exo, endo, entro) and their mode of actions; mechanisms of pathogenesis, and clinical manifestations associated with medically-important pathogenic microorganisms (bacteria, fungi, parasites, and viruses).

Unit- 6: Environmental microbiology

Role of microorganisms in the cycling of bioelements (carbon, nitrogen, phosphorus, sulphur, iron, manganese etc.); microbial degradation of pesticides and other recalcitrant chemicals, xenobiotics); microorganism in mineral recovery; microbial degradation of petroleum and hydrocarbons; biodeteriroration and control; microbial inoculants in agricultural: Biofertilizers- Biological Nitrogen fixation- symbiotic and asymbiotic, mass production by *Rhizobium*, *Azotobacter* and *Cyanobacteria*, nitrifying, ammonifying and photosynthetic bacteria; biological control.

Essential Reading:

1. Microbiology, M.J. Pelczar, E.C.S. Chan and N.R. Kreig, Tata McGraw Hill.
2. General Microbiology, R.Y. Stanier, J.L. Ingraham, M. L. Wheelis and P.R. Painter, Macmillian.
3. Microbial ecology: Fundamentals and Applications, 4 e, R.M. Atlas and R. Bartha, Pearson Education.
4. Molecular genetics of bacteria, 3 e, L. Snyder and W. Champness, ASM Press.
5. Biotechnology, B.D. Singh, Kalyani Publishers.
6. Gene cloning and DNA analysis: An introduction, T.A. Brown, Blackwell Publishing.

Supplementary Reading:

1. The microbes – An Introduction to their Nature and Importance, P.V. Vandenmark and B.L. Batzing Benjamin Cummings.
2. Microbiology, Tortora, Funke and Chase, Benzamin & Cummings
3. Microbiology, 5th Edition, Lansing M. Prescott
4. Brock biology of microorganisms, 12 e Michael Madigan, John Martinko, Paul Dunlap, David Clark, Pearson Education.
5. Microbial genetics, S. R. Maloy, J.E. Cronan, Jr., D. Freifelder, Narosa Publishing House.

LS 402 BIOCHEMISTRY 4 credits [3-1-0]

Amino acids: Nomenclature, structure and properties of amino acids- Ninhydrin test. Proteins: Peptide bond, Conformation of proteins (Ramachandran plot, secondary, tertiary and quaternary structure; domains, motif and folds). Lipids, Membrane structure and function- Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes. Concept of gene and genetics: Nucleic Acids, Structure of DNA and RNA, central dogma, central dogma reverse, genetic code. Principles of gene regulation: replication, transcription and translation. Carbohydrates: Structure of various sugars, including hexoses and pentoses. Concept of monosaccharides, disaccharides and polysaccharides. Glycolysis, TCA cycle and pentose phosphate pathway.

Photosynthesis and Pigments of life: Chlorophyll, Haemoglobin and Cytochrome c. Tetrapyrroles are responsible, *inter alia*, for oxygen transport (haem), electron transport (cytochrome c) and, most fundamentally, photosynthesis (chlorophyll).

Essential Reading:

1. Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson, Michael M. Cox, Hardcover: 1100 pages, Publisher: W. H. Freeman
2. Herpers Review of Biochemistry

Supplementary Reading:

1. Biochemistry by Donald Voet, Hardcover: 1616 pages, Publisher: Wiley; 3 edition
2. Biochemistry, L. Stryer, W.H. Freeman.
3. Biochemistry, J. David Rawan, Neil Patterson.

LS 403 IMMUNOLOGY 4 Credits [3-1-0]

Basic concepts in immunology, components of the immune system, Innate immunity, principles of innate and adaptive immunity, Different lines and layers of defense, Pattern recognition in innate immune system. The complement system, Induced innate responses to infections, Antigen recognition by B-cells, The structure of a typical antibody molecule, Interaction between the antibody and specific antigen, Diversity of Immunoglobulins: VDJ Recombination; Antigen recognition by T cells, Antigen processing and presentation: MHC, Complement system, Development and survival of lymphocytes, Lymphocytes in bone marrow and thymus, Positive and negative selection of lymphocytes, Survival and maturation of lymphocytes, The Adaptive Immune Response, T Cell-Mediated Immunity and cytotoxicity, Macrophage activation by armed CD4 TH1 cells, Humoral Immune Response ; Adaptive Immunity to Infection: Infectious agents and how they cause disease? The course of the adaptive response against infection, The mucosal immune system, Immunological memory; Failures of Host Defense Mechanisms, Inherited immunodeficiency diseases, Acquired immune deficiency syndrome, Allergy and Hypersensitivity, Effector mechanisms in allergic reactions and IgE, Hypersensitivity diseases, Autoimmunity and Transplantation, Autoimmune responses are directed against self antigens.

Essential Reading:

1. Delves, Martin, Burton &Roitt, *Essential Immunology*, 11th Edition.
2. Richard A. Golds by, Thomas J. Kindt and Barbara A. Osborne, *Kuby Immunology* I. K. International Pvt Ltd.

Supplementary Reading:

1. Janeway, Travers, Walport, and Shlomchik, *Immunobiology, the immune system in health and disease,* Garland Science Publishing, 6th Edition, 2005,
2. L. M. Sompayrac, *How the Immune System Works,* Wiley-Blackwell; 3rd edition.

LS 404 MOLECULAR BIOLOGY AND BIOTECHNOLOGY 4 credits [3-1-0]

Properties and evolution of genetic material, flow of genetic information and Isolation of genes. DNA Replication: Models of Replication, Origin of replication, DNA polymerases, DNA topology, DNA damage and repair. Transcription: RNA-polymerases, RNA processing, regulation, post-transcriptional control and degeneration, gene silencing. Translation: Structure of Ribosome, tRNA and mRNA, protein synthesis and regulation in prokaryotes and eukaryotes, protein sorting, signal peptides. Biosignaling: signal perception, molecular mechanisms of signal transduction, regulation of signal transduction pathways in controlling gene expression. Transposons and retrotransposons: prokaryotic and eukaryotic transposable elements and their role in evolution. Linkage and crossing over, Genetic recombination and construction of genetic maps in Drosophila, Interference and coincidence, Cytological demonstration of crossing over in Drosophila, Mitotic recombination, Intragenic recombination, Inheritance of quantitative traits, Continuous and discontinuous variation, Polygenic inheritance, Genetic variance, heritability (narrow sense and broad sense). ; Concept and definition of biotechnology: Microbial biotechnology, Culture system (batch, fed batch and continuous culture), Fermentor, output optimization, concept of downstream processing for product recovery, stain development of microorganisms, fermentation of antibiotics, organic acids and amino acids, single cell protein, microbial fuel production, microbial pestisides and biofertilizers. ; Enzyme engineering: Commercial use of enzymes, immobilization techniques and its application, various methods of immobilization, enzyme sensors, enzyme reactor and there utility. ; Animal biotechnology: cell culture, Monoclonal antibody, gene therapy, hybridoma technology, methods of vaccination, gene therapy, Application of recombinant DNA technology in medicine and diagnosis. Animal cloning. ; Plant biotechnology: Transgenic plants, herbiside and insecticide resistant plants

and there utility in modern day agriculture, chloroplast enginnering- production of moleculer H2 and chloroplast and photo voltaic system; Advantages of 89mmune89r898989ia as possible commercial source of molecular H2.

Essential Reading:

1. B. Lewin, *Genes VIII* by Hardcover, Publisher: Prentice Hall
2. B.D. Singh, *Biotechnology* by Kalyani Publishers 2009.
3. R. C. Dubey, *A text book of Biotechnology* by S. Chand and Co., India
4. J. K. Pal and S. S. Ghaskadbi, *Fundamentals of molecular biology* by Oxford University Press.

Supplementary Reading:

1. L. Stryer, *Biochemistry*
2. S. Cummings*, Current Perspectives in Genetics: Insights and Applications in Molecular, Classical, and Human Genetics*, 2000 Edition Paperback: 170 pages, Publisher: Brooks Cole

LS 405 CELL BIOLOGY 4 credits [3-1-0]

Structure and Function of Cell and its Organelles: Cell as the unit of life**-** Development of cell theory, Cell types: prokaryotes vs. eukaryotes; from single cell to multi-cellular organism; Prokaryotic cells: Structure, cell-walls and related molecules, outer membrane, flagella, motivity, cell inclusion endospores, gas vesicles, capsules, slime layers.

Cell Architecture: Cyto-skeletal components, microtubules and microfilaments, motility and motor motions, actomyosin complex , Extra-cellular matrix. Membrane system: Biological membranes – architecture & kinetics (transport, ion channels, diffusion, Na-K pump, proton pump). Endomembrane system: endoplasmic reticulum, Golgi complex, endosomes, lysosomes. Cell nucleus, Chromatin structure, nucleolus, nucleoplasm.

Cell Division: Mitosis, meiosis and cytokinetics, animal and yeast cell division, cell cycle control, programmed cell death. Cell cycle: G0/G1, S, G2 and M phages, duration of different phages and the methods for their determination, Cell cycle synchronization, arrest and delay in case of diseases. Protein localization: Synthesis of secretory & membrance protein, import into nucleus, mitochondria, chloroplast & peroxisome; Receptor-mediated endocytosis. Cellular communication: Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins.

Cell Signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component systems, light signaling in plants, bacterial chemotaxis and quorum sensing.

Specific pathways: Chromatin Regulation; Ras, MAPK and Ras-MAPK Signaling; Apoptosis/Autophagy, PI3K/Akt Signaling, Translational Control; Ca, cAMP & Lipid Signaling, Cell Cycle/Checkpoint, DNA Damage, Jak/Stat Pathway, NF-κB Signaling, TGF-β/Smad Signaling, Lymphocyte Signaling, Neuroscience, Tyrosine Kinase/Adaptors, Angiogenesis, Vesicle Trafficking, Cytoskeletal Signaling, Adhesion, Glucose Metabolism, Wnt/Hedgehog/Notch, Stem Cell/Lineage Markers, Nuclear Receptors.

Essential Reading:

1. Essential Cell Biology : An Introduction to the Molecular Biology of the Cell, B. Alberts, D. Bray, A. Johnson, J. Lewis, M. Roff, K. Robert, P. Walter and K. Roberts, Garland Publishing Company
2. Cell and Molecular Biology, DeRobertis, B .I. Publication Pvt. Ltd
3. Molecular Cell Biology, H. Lodish, A.Berk, S.L. Zipursky, P. Matsudaura, D. Baltimore and J. Danell, W.H. Preeman and Company.
4. Essential Cell Biology : An Introduction to the Molecular Biology of the Cell, B. Alberts, D. Bray, A. Johnson, J. Lewis, M. Roff, K. Robert, P. Walter and K. Roberts, Garland Publishing Company.
5. Structure and Function in Cell Signalling by John Nelson, Wiley.

6. The biochemistry of cell 90mmune90r90 by Ernst J. M. Helmreich, Oxford Uni Press

Supplementary Reading:

1. Cell in Development and Inheritance, E.B. Wilson, Macmillan

LS 406 FUNDAMENTALS OF CELL BIOLOGY 3 credits [3-0-0]

Structure and function of cell and its organelles. Cell as the unit of life- Development of cell theory, Cell types: prokaryotes vs. eukaryotes; from single cell to multi-cellular organism; Prokaryotic cells: Structure, cell-walls and related molecules, outer membrane, flagella, motivity, cell inclusion endospores, gas vesicles, capsules, slime layers

Cell architecture, cyto-skeletal components, microtubules and microfilaments, motility and motor motions, actomyosin complex. Membrane system: Biological membranes – architecture & kinetics (transport, ion channels, diffusion, Na-K pump, proton pump). Endomembrane system: endoplasmic reticulum, Golgi complex, endosomes, lysosomes. Cell 90mmune90r9090:- Membrane domains, Lipid rafts, messengers and receptors. Extra-cellular matrix, Cell nucleus, Chromatin structure, nucleolus, nucleoplasm. Energy Transduction and Bioenergetics: Mitochondria, ATP, Chemiosomes, ATPase, Gap junctions Chloroplast –photosynthetic electron transport, Calvin cycle. Anti-reductionism: Cell division: Mitosis, meiosis and cytokinetics, animal and yeast cell division, cell cycle control, programmed cell death. Cell cycle: G0/G1, S, G2 and M phages, duration of different phages and the methods for their determination, Cell cycle synchronization, arrest and delay in case of diseases. Protein localization: Synthesis of secretory & membrance protein, import into nucleus, mitochondria, chloroplast & peroxisome; Receptor-mediated endocytosis.

Essential Reading:

1. Essential Cell Biology : An Introduction to the Molecular Biology of the Cell, B. Alberts, D. Bray, A. Johnson, J. Lewis, M. Roff, K. Robert, P. Walter and K. Roberts, Garland Publishing Company
2. Cell and Molecular Biology, DeRobertis, B .I. Publication Pvt. Ltd
3. Molecular Cell Biology, H. Lodish, A.Berk, S.L. Zipursky, P. Matsudaura, D. Baltimore and J. Danell, W.H. Preeman and Company.
4. Essential Cell Biology : An Introduction to the Molecular Biology of the Cell, B. Alberts, D. Bray, A. Johnson, J. Lewis, M. Roff, K. Robert, P. Walter and K. Roberts, Garland Publishing Company

Supplementary Reading:

1. Cell in Development and Inheritance, E.B. Wilson, Macmillan

LS 410 FOOD SCIENCE 4 credits [3-1-0]

Unit- 1: Principles of food processing and preservation

Scope and importance of food processing: national and international perspectives, Principles of Preservation methods, fermentation methods for preservation, and chemical preservations of foods. Food preservation by low-temp: Refrigeration, freezing and freeze-drying. Food preservation by heating: drying, osmotic dehydration, blanching, canning, pasteurization, sterilization, extrusion cooking. Non-thermal preservation: Hydrostatic pressure, dielectric heating, microwave processing, hurdle technology, membrane technology, irradiation.

Unit- 2: Food chemistry

Food chemistry-definition and importance, Carbohydrates-chemical reactions, functional properties of sugars and polysaccharides in foods. Applications and preparations of sugars and polysaccharides. Protein and amino acids: structure, classifications, sources, denaturation and functional properties of proteins. Lipids: classification, and use of lipids in foods, physical and chemical properties, effects of processing on functional properties. Vitamins and Minerals, Effect of processing on vitamins and minerals. Enzymatic browning in foods and industrial applications of enzymes. Water in food, water activity and shelf life of food.

Unit- 3: Principles of food engineering

Unit operation in food engineering, Mass and energy balance, Fluid flow, fluid statics, fluid dynamics, fluid flow applications, Heat transfer-modes of heat transfer, conduction,
convection, and radiation, heat exchangers and their designs. Thermal processing- vaporation and concentration, dehydration, drying, blanching, pasteurization, sterilization, distillation and crystallization. Mechanical separation-filtration, membrane concentration, sieving, centrifugation, sedimentation, Mechanical handling-conveying and elevation. Size reduction and classification-mixing, kneading, blending.

Unit- 4: Fermentation technology

Introduction to fermentation: Rate of microbial growth and death. Fermentation kinetics, Types of fermentation sub-merged/solid state, Batch /continuous fermentation. Fermenter design, operation, measurement and control in fermentation, Aeration and agitation in fermentation: Oxygen requirement, measurement of adsorption coefficients, sterilization of air and media; scale up in fermentation. Production of beer, wine and vinegar, Traditional fermented foods like idli and dosa. Principles of down stream processing and Product recovery. Production of alcohols, organic acids, enzymes and immobilization of enzymes.

Unit- 5: Food quality and safety management

Objectives, importance and functions of quality control. Methods of quality, assessment
of food materials-fruits, vegetables, cereals, dairy products, meat, poultry, egg and processed food products. Sanitation and hygiene, GMP, GLP, Statistical quality control. Food laws and standard, PFA, AGMARK. Sampling and specification of raw materials and finished products, Concept of Codex Almentarious/ /USFDA/ISO 9000 series, rules and regulations for waste disposals. Food adulteration and food safety. HACCP, Sensory evaluation-introduction, panel screening, Sensory and instrumental analysis in quality control, IPR and patents.

Essential Reading:

1. Food Science, by Norman N. Potter and Joseph H. Hotchkiss
2. New Text Book on Food Science and technology, editor Geoffrey Cambell-Platt, Scientific publishers and Reviews

LS 411 BIOPHYSICS 4 credits [3-1-0]

Thermodynamic Principles: Laws of thermodynamics, Details of thermodynamic variables and functions. Application of there laws in Life Science with examples. **Basic atomic and radiation physics**. Electromanetic properties of light and basic molecular physics. Interaction of UV, VIS and IR radiation and LASER with bio-molecules and living system, Bio- and chemi-luminescence, photochemical reaction. Thermal changes in cells and tissues, thermal 91mmune91r91 in biological tissues, Biological transport processes, Nernst potential and Donnan potential – surface potential and potential across bio-membranes, biological energy conversion. **Electromagnetic energy spectrum – their effects on the molecules and method of studying them**, Raman, NMR, NOESY and TOCSY, ESR spectroscopy and Mass spectrometry, and their biological applications, optical rotatory dispersion, fluorescence, phosphorescence spectroscopy, circular dichroism, X-ray diffraction (structure of DNA, RNA and Proteins), ultrastructure determination, electron microscopy – transmission and scanning. Concept of liquid crystals, Principal component analysis, Matrices, analysis of spectral data with MetLab. **Radioactivity:** Radio emission, law of radioactive decay, production of radio isotopes for medical use, electromagnetic radiation, interaction of radiation with matter, exponential attenuation, half value thickness, photo electric, Compton and pair production process and their significance in radiology, radiation units, detection and measurements of radiation ; Introduction of ultrasonic wave: Ultrasonic wave motion, wave characteristics, intensity, and ultrasound properties in body. Use of ultrasound in biological field.

Essential Reading:

1. Biochemistry by L. Stryer, W.H. Freeman and Co.
2. A biologists physical chemistry by J. G. Morris, Edward Arnold (Publishers) Ltd.

Supplementary Reading:

1. Textbook of Biophysical Chemistry by U. N. Dash, MacMillan

A Textbook of Biophysics by R.N. Roy, New Central Book Agency

LS 412 ADVANCED MICROBIAL GENETICS 4 credits [3-1-0]

Unit – 1: DNA Structure and Mutagenesis

Historical developments in genetics, discovery of DNA and experimental evidence, Structure of Circular DNA molecule, Primary, Secondary, Tertiary and Quaternary structure of DNA, Watson and Crick model of double stranded DNA the law of DNA constancy and C value paradox and topological manipulations.

DNA replication: DNA replication mechanism, enzymes involved in DNA replication and models of DNA replication. Molecular basis of spontaneous and induced mutations [physical and chemical mutagenic agents], types of mutation: point, frameshift, lethal, conditional lethal, inversion and deletion, null mutation, reversion of mutations, intra and intergenic suppression mutations. Environmental mutagenesis, toxicity testing and population genetics. Systems that safeguard DNA. DNA methylation and DNA repair mechanisms – excision, mismatch, SOS , photoreactivation, recombination repair and glycocylase system.

Unit – 2: Prokaryotic Transcription and Translation

Organization of transcriptional units and regulation of gene expression Mechanism of transcription of prokaryotes-Structure and function of RNA polymerase, [DNA foot printing], termination and antitermination – N proteins and nut sites in DNA binding proteins, enhancer sequences and control of transcription, RNA processing (Capping, polyadenylation, splicing, introns and exons) Ribonucleoprotein, structure of mRNA, rRNA, tRNA. Direction of protein synthesis, RNA template, direction with experimental proof, tRNA as adaptor, ribosomes and their organization in prokaryotes, polycistronic mRNA in bacteria, initiation of translation in bacteria, small sub-units, its accessory factors, SD sequence in bacteria, initiator tRNA, elongation of translation, translocation and termination mechanisms. Post-translational modification. Salient features of genetic code.

Unit – 3: Regulation of gene expression in prokaryotes

Operon concept, co-ordinated control of structural genes, stringent response, catabolite repression, instability of bacterial RNA, positive regulation in E.coli [Arabinose operon] and negative regulation in E.coli [lac operon], inducers and repressors, regulation by attenuation by trp operon.

Unit – 4: Genetic recombination

Genetic recombination processes: Role of rec proteins in homologous recombination. Conjugation: Discovery, F+, F- and Hfr cells, types of Hfr; F+ and F- and Hfr and F- genetic crosses. Mechanism of conjugation. Sexduction, conjugational transfer of colicinogenic and resistance transfer factors. Genetic mapping. Plasmid Replication and Incompitability, Control of copy number.

Transposons – Insertion sequences and composite transposons, phages as transposons, replicative, non-replicative and conservative transposition. Mutations i.e. deletions, inversions and frameshift due to transposition. Mechanism of transposition, controlling elements of maize – autonomous and non-autonomous elements. Types of transposons and their properties.

Unit – 5: Phage Genetics

T4 virulent phage: structure, life cycle, genetic map and DNA replication. Lamda temperate phage: Structure, genetic map, lytic and lysogenic cycle, lysogenic repression and phage immunity. [Lambda regulon] applications of phages in microbial genetics.

Essential Reading:

1. Molecular genetics of bacteria by J. Dale and S. Park, Wiley

Microbial genetics by S. R. Maloy, Jones and Bartlett Publishers Inc.

LS 413 BASIC BIOPHYSICS 3 credits [3-0-0]

Thermodynamic Principles: Laws of thermodynamics, Details of thermodynamic variables and functions. Application of there laws in Life Science with examples. **Basic atomic and radiation physics**. Electromanetic properties of light and basic molecular physics. Interaction of UV, VIS and IR

radiation and LASER with bio-molecules and living system, Bio- and chemi-luminescence, photochemical reaction. Thermal changes in cells and tissues, thermal 93mmune93r93 in biological tissues, Biological transport processes, Nernst potential and Donnan potential – surface potential and potential across bio-membranes, biological energy conversion. **Electromagnetic energy spectrum – their effects on the molecules and method of studying them**, Raman, NMR, NOESY and TOCSY, ESR spectroscopy and Mass spectrometry, and their biological applications, optical rotatory dispersion, fluorescence, phosphorescence spectroscopy, circular dichroism, X-ray diffraction (structure of DNA, RNA and Proteins), ultrastructure determination, electron microscopy – transmission and scanning. Concept of liquid crystals, Principal component analysis, Matrices, analysis of spectral data with MetLab. **Radioactivity:** Radio emission, law of radioactive decay, production of radio isotopes for medical use, electromagnetic radiation, interaction of radiation with matter, exponential attenuation, half value thickness, photo electric, Compton and pair production process and their significance in radiology, radiation units, detection and measurements of radiation ; Introduction of ultrasonic wave: Ultrasonic wave motion, wave characteristics, intensity, and ultrasound properties in body. Use of ultrasound in biological field.

Essential Reading:

1. Biochemistry by L. Stryer, W.H. Freeman and Co.
2. A biologists physical chemistry by J. G. Morris, Edward Arnold (Publishers) Ltd.

Supplementary Reading:

1. Textbook of Biophysical Chemistry by U. N. Dash, MacMillan
2. A Textbook of Biophysics by R.N. Roy, New Central Book Agency

LS 414 MICROBIAL GENETICS 3 credits [3-0-0]

Unit – 1: DNA Structure and Mutagenesis

Historical developments in genetics, discovery of DNA and experimental evidence, Structure of Circular DNA molecule, Primary, Secondary, Tertiary and Quaternary structure of DNA, Watson and Crick model of double stranded DNA the law of DNA constancy and C value paradox and topological manipulations.

DNA replication: DNA replication mechanism, enzymes involved in DNA replication and models of DNA replication. Molecular basis of spontaneous and induced mutations [physical and chemical mutagenic agents], types of mutation: point, frameshift, lethal, conditional lethal, inversion and deletion, null mutation, reversion of mutations, intra and intergenic suppression mutations. Environmental mutagenesis, toxicity testing and population genetics. Systems that safeguard DNA. DNA methylation and DNA repair mechanisms – excision, mismatch, SOS , photoreactivation, recombination repair and glycocylase system.

Unit – 2: Prokaryotic Transcription and Translation

Organization of transcriptional units and regulation of gene expression Mechanism of transcription of prokaryotes-Structure and function of RNA polymerase, [DNA foot printing], termination and antitermination – N proteins and nut sites in DNA binding proteins, enhancer sequences and control of transcription, RNA processing (Capping, polyadenylation, splicing, introns and exons) Ribonucleoprotein, structure of mRNA, rRNA, tRNA. Direction of protein synthesis, RNA template, direction with experimental proof, tRNA as adaptor, ribosomes and their organization in prokaryotes, polycistronic mRNA in bacteria, initiation of translation in bacteria, small sub-units, its accessory factors, SD sequence in bacteria, initiator tRNA, elongation of translation, translocation and termination mechanisms. Post-translational modification. Salient features of genetic code.

Unit – 3: Regulation of gene expression in prokaryotes

Operon concept, co-ordinated control of structural genes, stringent response, catabolite repression, instability of bacterial RNA, positive regulation in E.coli [Arabinose operon] and negative regulation in E.coli [lac operon], inducers and repressors, regulation by attenuation by trp operon.

Unit – 4: Genetic recombination

Genetic recombination processes: Role of rec proteins in homologous recombination. Conjugation: Discovery, F+, F- and Hfr cells, types of Hfr; F+ and F- and Hfr and F- genetic crosses. Mechanism of

conjugation. Sexduction, conjugational transfer of colicinogenic and resistance transfer factors. Genetic mapping. Plasmid Replication and Incompitability, Control of copy number.
Transposons – Insertion sequences and composite transposons, phages as transposons, replicative, non-replicative and conservative transposition. Mutations i.e. deletions, inversions and frameshift due to transposition. Mechanism of transposition, controlling elements of maize – autonomous and non-autonomous elements. Types of transposons and their properties.

Unit – 5: Phage Genetics

T4 virulent phage: structure, life cycle, genetic map and DNA replication. Lamda temperate phage: Structure, genetic map, lytic and lysogenic cycle, lysogenic repression and phage immunity. [Lambda regulon] applications of phages in microbial genetics.

Essential Reading:

1. Molecular genetics of bacteria by J. Dale and S. Park, Wiley
2. Microbial genetics by S. R. Maloy, Jones and Bartlett Publishers Inc.

LS 420 APPLIED BIOINFORMATICS 4 credits [3-1-0]

Introduction to computational biology & bioinformatics. Branches of bioinformatics. Nature of biological data. Biological data formats. Bioinformatics databases: Literature databases (PubMed), Primary nucleotide sequence databases (NCBI, EMBL, DDBJ), Secondary nucleotide sequence databases (UniGene, SGD etc.), Protein sequence databases (SwissProt/TrEMBL, PIR), Sequence motif databases (Pfam, PROSITE), Structure databases (PDB, NSD, SCOP, CATH), Gene Expression databases. Algorithms and bio-tools: Sequence alignment and database similarity searching. Scoring matrix, BLAST series, FASTA. Pairwise Sequence Alignments and Multiple sequence alignments (ClustalW). Global Alignments – Needleman Wunsch Algorithm, Local Alignments – Smith Waterman Algorithm. Multiple sequence alignments (ClustalW). Basic concepts on phylogenetic markers and molecular phylogeny. Comparative genomics and gene prediction tools. Structural bioinformatics: prediction of secondary & tertiary structure of proteins, comparative modeling. Molecular viewers. Concept of in-silico drug design. Vaccine design concept. Human genome and epigenome projects. Overview of programming languages in bioinformatics. Basic commands of UNIX. Other biological tools and resources: EMBOSS, Expasy, OMIM, GOLD etc.

Essential Reading:

1. Bioinformatics: Principles and Applications by Z. Ghosh and B. Mallick, Oxford University Press.
2. Bioinformatics: Sequence and Genome Analysis by D.W. Mount, Cold Spring Harbor Laboratory Press
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins by A.D. Baxevanis and B.F.F. Ouellette, Wiley-interscience.
   Understanding Bioinformatics by Marketa Zvelebil and Jeremy Baum, Garland Science.

LS 421 RADIATION BIOLOGY 4 credits [3-1-0]

Basic concept of electromagnetic radiations, radiation dose and dosimetry. Photolysis of water, UV-radiation induced damage to DNA and various repair pathways. Rapidly accumulating advancement in the field of Radiobiology, Radio-oncology, Diagnostic Radiology.

Essential Reading:

6. Introduction to radiation biology by Devi Nagarathnam and Rao, B. I. Churchil Livingstone

LS 422 CELL CELL SIGNALING 4 credits [3-1-0]

A. Cell signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component signaling systems, bacterial chemotaxis and quorum sensing.
B. Cellular communication: Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.
C. Cancer : Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth.
D. Specific pathways:- Chromatin Regulation; Ras, MAPK and Ras-MAPK Signaling; Apoptosis/Autophagy, PI3K/Akt Signaling, Translational Control; Ca, cAMP & Lipid Signaling, Cell Cycle/Checkpoint, DNA Damage, Jak/Stat Pathway, NF-κB Signaling, TGF-β/Smad Signaling, Lymphocyte Signaling, Neuroscience, Tyrosine Kinase/Adaptors, Angiogenesis, Vesicle Trafficking, Cytoskeletal Signaling, Adhesion, Glucose Metabolism, Wnt/Hedgehog/Notch, Stem Cell/Lineage Markers, Nuclear Receptors.

Essential Reading:

1. Molecular Biology of the cell by Bruce Alberts et al, Garland Science Com
2. Molecular cell Biology by Lodish et al, W H Freeman and Company
3. Structure and Function in Cell Signalling by John Nelson, Wiley.
4. The biochemistry of cell 95mmune95r95 by Ernst J. M. Helmreich, Oxford Uni Press

LS 423 ADVANCED TECHNIQUES 4 credits [3-1-0]

Spectroscopy – Concepts of spectroscopy, Visible and UV spectroscopy, Laws of photometry. Beer-Lambert's law, Principles and applications of colorimetry, Mass Spectroscopy, LC-MS, LC-MS-MS, GC-MS-MS

Chromatography – Dialysis, Principles of partition chromatography, paper, thin layer, ion exchange and affinity chromatography, gel permeation chromatography, HPLC and FPLC

Centrifugation – Principles 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

Electrophoretic techniques – Principles of electrophoretic separation. Continuous, zonal and capillary electrophoresis, different types of electrophoresis including paper, cellulose, acetate/nitrate and gel. Electroporation, pulse field gel electrophoresis, EMSA, DNA fingerprinting, and foor printing.

Molecular Biology techniques- Hybridization and blotting, PCR, RT-PCR, Real time PCR, RFLP, AFLP, Chromosome walking, chromosome jumping, DNA microarray, chips and RIA. Methods of DNA sequencing: Sangers sequencing, 454 sequencing. Analysis of SINES and LINES. Genomic insulators.

Electron microscopy – Transmission and scanning, freeze fracture techniques, specific staining of biological materials. Spectroscopic techniques: Absorption, Florescence, ORD, CD, X-ray diffraction, X-ray absorption, and NMR.

Advances in Viscosity and surface tension measurement– Viscosity of macromolecules, relationship with conformational changes.

Essential Reading:

1. Principles of Biochemistry and molecular biology by K. Wilson and J. Walker, Cambridge University Press.
2. Principles of Instrumental analysis by D. A. Skoog and J. J. Leary, Saunders College Publishing, Philadelphia

LS 424 GENOMICS & PROTEOMICS 4 credits [3-1-0]

Definition, classification, and scopes. The emergence of proteome concept: structural and functional proteomes, protein structure related to functional kinetics, e.g. prions, bridging genomics to proteomics. Transcriptomes: measurement of gene expression. Proteome analysis: by methods, 2-D

PAGE including protein detection on electro-blot membrane, mass spectrometry and phosphorylation site analysis. Proteomics in relation to animal and plant health and welfare.

Essential Reading:

1. A Textbook of Protein and Proteomics, C Subramanian and Nandan Hazare, Dominant Pub.
2. Discovering Genomics, Proteomics and Bioinformatics (2nd Edition), by A. Malcolm Campbell and Laurie J. Heyer.

LS 425 INTRODUCTION TO BIOINFORMATICS 3 credits [3-0-0]

Basic concepts, Introduction to biological databases and tools. Sequence and structure databases. Sequence alignments: Pairwise and Multiple Sequence Alignment, Methods and algorithms used in alignment tools: Methods for doing Multiple Sequence Alignments: CLUSTALW and PILEUP. BLAST series and FASTA. Phylogenetic analysis: Concept and methods: Distance based (Fitch and Margoliash & UPGMA) and character based methods (Parsimony). Prediction of genes and tools. Structural bioinformatics and molecular modelling. Human genome and epigenome projects. Introduction of protein structure and prediction. Useful biological tools and resources for biological research, eg. EMBOSS, Expasy, OMIM, GOLD etc. Introduction to bio-programming languages. Some basic commands of UNIX.

Essential Reading:

1. Bioinformatics: Principles and Applications by Z. Ghosh and B. Mallick, Oxford University Press.
2. Bioinformatics: Sequence and Genome Analysis by D.W. Mount, Cold Spring Harbor Laboratory Press.

LS 427 ADVANCED TECHNIQUES 3 credits [3-0-0]

Spectroscopy – Concepts of spectroscopy, Visible and UV spectroscopy, Laws of photometry. Beer-Lambert's law, Principles and applications of colorimetry, Mass Spectroscopy, LC-MS, LC-MS-MS, GC-MS-MS

Chromatography – Dialysis, Principles of partition chromatography, paper, thin layer, ion exchange and affinity chromatography, gel permeation chromatography, HPLC and FPLC

Centrifugation – Principles 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

Electrophoretic techniques – Principles of electrophoretic separation. Continuous, zonal and capillary electrophoresis, different types of electrophoresis including paper, cellulose, acetate/nitrate and gel. Electroporation, pulse field gel electrophoresis, EMSA, DNA fingerprinting, and foor printing.

Molecular Biology techniques- Hybridization and blotting, PCR, RT-PCR, Real time PCR, RFLP, AFLP, Chromosome walking, chromosome jumping, DNA microarray, chips and RIA. Methods of DNA sequencing: Sangers sequencing, 454 sequencing. Analysis of SINES and LINES. Genomic insulators.

Electron microscopy – Transmission and scanning, freeze fracture techniques, specific staining of biological materials. Spectroscopic techniques: Absorption, Florescence, ORD, CD, X-ray diffraction, X-ray absorption, and NMR.

Advances in Viscosity and surface tension measurement– Viscosity of macromolecules, relationship with conformational changes.

Essential Reading:

1. Principles of Biochemistry and molecular biology by K. Wilson and J. Walker, Cambridge University Press.
2. Principles of Instrumental analysis by D. A. Skoog and J. J. Leary, Saunders College Publishing, Philadelphia

LS 435 MICROBIAL DIVERSITY AND EXTREMOPHILES 3 credits [3-0-0]

Unit – 1: Biodiversity

Introduction to microbial biodiversity – distribution, abundance, ecological niche. Types-Bacterial, Archael and Eucaryal.

Unit – 2: Characteristics and classification of Archaebacteria

Thermophiles: Classification, hyperthermophilic habitats and ecological aspects. Extremely Thermophilic Archaebacteria, Thermophily, commercial aspects of thermophiles. Applications of thermozymes. Psychrophiles. Methanogens: Classification, Habitats, applications.

Unit – 3: Alkalophiles and Acidophiles

Classification, alkaline environment, soda lakes and deserts, calcium alkalophily Applications. Acidophiles: Classification, life at low pH, acidotolerence, applications.

Unit – 4: Halophiles and Barophiles

Classification, Dead Sea, discovery basin, cell walls and membranes – Purple membrane, compatible solutes. Osmoadaptation / halotolerence. Applications of halophiles and their extremozymes. Barophiles: Classification, high-pressure habitats, life under pressure, barophily, death under pressure.

Unit – 5: Space Microbiology

Aims and objectives of Space research. Life detection methods a] Evidence of metabolism (Gulliver) b] Evidence of photosynthesis (autotrophic and heterotrophic) c] ATP production d] Phosphate uptake e] Sulphur uptake . Martian environment (atmosphere, climate and other details). Antartica as a model for Mars. Search for life on Mars, Viking mission, Viking landers, and Biology box experiment. Gas exchange , Label release and pyrolytic release experiments. Monitoring of astronauts microbial flora: Alterations in the load of medically important microorganisms, changes in mycological autoflora, and changes in bacterial autoflora.

Essential Reading:

1. Extremophiles: Microbial life in extreme environments by K. Horikoshi and W. D. grant, Wiley Liss
2. Physiology and biochemistry of Extremophiles by C. Gerday and N. Glansdorff, ASM Press.

LS 440 PHYSICAL SCIENCES AND INSTRUMENTATION 4 credits [3-1-0]

Physical sciences

Reductionism vs. holistic view of living system, Debate on the definition of Life:- Molecular view: Koshland's concept – Seven Pillars of Life: Program, Improvisation, Compartmentalization, Energy, Regeneration, Adaptability, and Seclusion (PICERAS). Thermodynamics Principles: laws of thermodynamics, Details of thermodynamic variables and functions. Application of thermodynamics to biology. Structure of atoms, molecules and chemical bonds. Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Stablizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). Water structure and polarity. Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties). Stereochemistry: Configuration and conformation and stability; Elements of symmetry, Chirality; RS-, EZ, DL- and dl- system of nomenclature; Stereo-specific and stereo-selective reactions; Determination of relative configuration by asymmetric synthesis.

Instrumentation

Unit- 1: Chromatography

Paper, TLC, gel filtration, ion-exchange chromatography, affinity chromatography, HPLC and GLC.

Unit- 2: Microscopy

Optical microscopy, Bright field, Dark field, phase contrast and fluorescence microscopy. Electron microscopy: Transmission and scanning electron microscopy.

Unit- 3: Centrifugation

Principle of centrifugation, rotors, different types of centrifuges, preparative and analytical centrifugation, ultra centrifugation.

Unit- 4: Electrophoresis

Gel electrophoresis, SDS-PAGE, isoelectric focusing, two –dimensional electrophoresis, 98mmune electrophoresis, capillary electrophoresis.

Unit- 5: Spectroscopy

Atomic Absorption, spectrophotometry, Mass spectrometry, NMR.

Essential Reading:

1. Principles of Biochemistry and molecular biology by K. Wilson and J. Walker, Cambridge University Press.
   Principles of Instrumental analysis by D. A. Skoog and J. J. Leary, Saunders College Publishing, Philadelphia

LS 471 MICROBIOLOGY LABORATORY 2 credits [0-0-3]

1. To study the guidelines for working in microbiology laboratory.
2. To acquaint with the instrument used in microbiology laboratory
3. To study the various aseptic techniques used in microbial experiment.
4. To prepare various liquid and solid media used in microbiology experiment.
5. To isolate and count total heterotrophic bacteria in soil sample.
6. To isolate and count total heterotrophic microbes from air.
7. To isolate and count total heterotrophic bacteria in water sample.
8. To isolate pure culture from mixed culture by streak plate method
9. To perform fungal staining for the study of fungal morphology.
10. To perform simple staining and to compare the morphological shape and arrangements' of bacteria cells.
11. To perform gram staining or differential staining to study the bacterial morphology and distinguish between gram positive and gram negative bacteria.
12. To test starch hydrolysis by amylase activity
13. To test protein hydrolysis by gelatin degradation.
14. Preparation of agar slant
15. To study catalase activity
16. To study motility of bacteria by tube method.
17. MPN
18. Antibiotic sensitivity test
19. IMViC test
20. Isolation of Actinobacteria from soil samples.

LS 472 BIOCHEMISTRY LABORATORY 2 credits [0-0-3]

1. Estimation of blood glucose, detection of serum- (i) urea, (ii) uric acid, (iii) creatine, (iv) creatinine and (v) bile pigment
2. Blood grouping (ABO – Rh)
3. Determination of urine sample for (i) sugar, (ii) ketone bodies, (iii) protein
4. Estimation of Hb concentration, total W.B.C and R.B.C count in blood
5. Determination of lipid, total cholesterol, LDL and HDL and triglycerides
6. Enzymology – purification of enzyme & its kinetics
7. Study of the cell – (i) Cell culture, lymphocyte isolation & culture, growth rate studies, staining techniques (ii) Cell fractionation, homogenization of the tissue, centrifugation, marker enzyme assays (iii) Microscopy and microphotography.
8. Quantitative assays – (i) Enzyme assays (ii) RIA (iii) ELISA iv) DNA, RNA & proteins

9. Protein fractionation – (i) Salting in and out, gel filtration, electrophoretic separation (ii) Gel filtration affinity based techniques (iii) SDS-PAGE (iv) Electrophoretic separation of LDH isoenzymes
10. Absorption & fluorescence spectroscopy related experiments
11. Determination of CMC of biological surfactants.

LS 473 BIOTECHNOLOGY LABORATORY 2 credits [0-0-3]

1. Quantitation of nucleic acids (Spectrophotometric, Gel based and Saran wrap method)
2. Analysis of DNA fragments and size determination by agarose gel electrophoresis
3. Restriction digestion and ligation
4. Restriction mapping
5. Southern blotting
6. Western blotting
7. PCR and RT-PCR
8. Optimization of gene expression in *E.coli* and analysis of expressed product
9. Methods for enzyme immobilization

LS 474 MOLECULAR BIOLOGY LABORATORY 2 credits [0-0-3]

1. Determination of Isobestic points
2. Determination of melting point of DNA (Calf thymus, Whale Sperm)
3. Isolation of chromosomal DNA from *E.coli* and plants.
4. Isolation of RNA from mammalian cells (sources- horse, rat, rabbit etc.)
5. SDS-PAGE of protein.
6. Isolation of plasmid DNA from *E.coli.*
7. Transformation of *E.coli* with plasmid.
8. UV induced mutagenesis in *E. coli*
9. Tissue culture

LS 475 IMMUNOLOGY LABORATORY 2 credits [0-0-3]

1. Study of Blood Groups
2. Study of Antigen- Antibody pattern-ODD
3. Immunoglobulin Y purification
4. Immunoglobulin G purification
5. Study of immunohistochemistry
6. Study of Latex agglutination
7. Study of haem agglutination
8. Study of antibody-FITC conjugation

LS 502 ADVANCES IN STRUCTURAL BIOLOGY 4 credits [3-1-0]

A familiarity with the NMR, X-ray, and computational techniques used to study macromolecular structure, motions in macromolecules and the functional importance of dynamics, the basis for various types of macromolecular interactions including protein- protein and protein-nucleic acid interactions, evolutionary relationships of structural features, the determinants of protein structure and an understanding of the current views of protein folding, the chemical basis for interactions with enzyme inhibitors and other ligands. History of Structural Biology: X-ray crystallographic and NMR-structure of Proteins, and Nucleic acids. Proposition of DNA double helical structure in understanding the blue-print of life- Watson & Crick model. Fine structure of Proteins- fibrous, globular and membrane proteins, Nucleosome and Chromatin structure. Cytoskeleton structure and protein-protein Network, Muscle proteins. Structure of Heart, Lung and Brain.

Essential Reading:

1. Textbook of Structural biology by Anders Lilgas, Lars Lilgas, Jui Piskur et al, World Scientific Publisher
2. Advances in structural biology by S. K. Malhotra (Editor), Elsevier.
3. Membrane structural biology by Mary Luckey, Barnes and Noble Publisher.

LS 503 RECOMBINANT DNA TECHNOLOGY 3 credits [3-0-0]

Unit- 1: Introduction to the subject and the tools used in RDT

Restriction endonuclease, methyltransferase, ligase, polymerase, kinase, phosphatase, nuclease, transferase, reverse transcriptase, linkers, adapters DNA, RNA and protein markers.

Unit- 2: Overview of cloning vectors

Plasmids, bacteriophages (Lambda and M13), phagemids, cosmids, artificial chromosomes (YAC, BAC).

Unit- 3: Blotting techniques. Hybridization and Nucleic acid amplification

Southern, Northern and Western blotting techniques. Radioactive and non-radioactive probes. Basics of PCR, site directed mutagenesis.

Unit- 4: Cloning and selection of clones

Basic cloning experiment: Design of cloning strategy and stepwise experimental procedure including application of tools introduced in module I. Complementation, colony and plaque hybridization, restriction, PCR, plus-minus screening, immunoscreening.

Unit- 5: Heterologous gene expression

Overview of expression vectors (Bacteria and yeast), vector engineering (fusion tags, antibiotic markers), codon optimization, host engineering

Unit- 6: DNA Libraries

Purpose of constructing DNA libraries. Construction of cDNA and genomic libraries.

Unit- 7: Advanced techniques in RDT

Primer extension mapping, S1 mapping, Rnase protection assay, two and three hybrid systems, subtractive hybridization, gel retardation assay, Dnase footprinting, *in vitro* transcription and translation, phage display, DNA sequencing (Maxam Gilbert, Sanger's and automated), protein engineering.

Essential Reading:

1. Principles of Gene Manipulation: An Introduction to Genetic Engineering, R.W. Old and S. B Primrose, Blackwell Science Inc.
2. DNA Cloning: A Practical Approach, D.M. Glover and B.D. Hames, IRL Press.
3. Molecular Cloning: A Laboratory Manual, J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor, Laboratory Press.

Supplementary Reading:

1. Molecular Biotechnology: Principles and Applications of Recombinant DNA, B.R. Grick and J.J. Pasternak, ASM Press
2. Molecular and Cellular Cells Methods in Biology and Medicine, P.B Kaufman, W. Wu, D. Kim and C.J. Cseke, CRC Press.
3. Milestones in Biotechnology: Classic Papers on Genetic Engineering, J.A. Bavies and W.S. Reznikoff, Butterworth Heinemann.

LS 504 ENVIRONMENTAL SCIENCES AND BIOSTATISTICS 4 credits [3-1-0]

Unit- 1: Scope of ecology and environmental sciences

Definition, principles and scope of ecology and environmental sciences. Earth, man and environment. Ecosystems- pathways in Ecosystems. Physico-chemical and Biological factors in the environment. Geographical classification and zones. Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere.

Unit- 2: Ecosystem structure and functions

Ecosystems: Structure and functions, abiotic and biotic components, energy flows. Food chains, food web, ecological pyramids, types and diversity. Energy flow and mineral cycling (CNP).

Unit- 3: Habitat and ecological components

Habitat and niche: Concept of habitat and niche; fundamental and realized niche.

Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection);

Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement.

Ecological succession: Types; mechanisms; changes involved in succession; concept of climax.

Unit- 4: Biogeography and conservation biology

Major terrestrial biomes; theory of island biogeography; biogeographical zones of India. Environmental pollution. Principles of conservation, major approaches to management.

Unit- 5: Collection and presentation of data

Collection of biological data: sampling, aim, techniques- random sampling and non-random sampling. Classification of data, frequency distribution and tabulation. Graphical representation- bar diagram, pie diagram, frequency curve, histogram, Ogive.

Unit- 6: Statistics of location and dispersion

Measures of central value- Mean, Median, Mode. Measures of dispersion- standard deviation, coefficient of variation. Skewness and Kurtosis.

Unit- 7: Sampling statistics and testing of hypothesis

Procedure for testing hypothesis. Test of significance based on small samples and large samples ('t' test and 'z' test), Chi-square test, Analysis of variance- One-way and Two-way ANOVA.

Unit- 8: Correlation and regression

Use of correlation in biological science – purpose, positive correlation, negative correlation, calculating correlation coefficient, significance. Use of Regression in Biological Sciences – purpose, coefficient of regression (b), Regression line (Y on X and X on Y).

Essential Reading:

1. Fundamentals of Ecology by E. P. Odum and G. W. Barrett, Cengage Learning
2. Environmental Science by S. C. Santra, New Central Book Agency, India.
3. Ecology and Environment by P. D. Sharma, Rastogi Publications, India.
4. Fundamentals of statistics by S.C. Gupta, Himalaya Publishing House
5. Biostatistical analysis by J. H. Zar, Prentice Hall.
6. Quantitative Zoology by G. G. Simpson, A. Roe and Dover Publications.

Supplementary Reading:

1. Ecology by P. J. Russell, S. L. Wolfe, P. E. Hertz, C. Starr and B. McMillan, Cengage Learning
2. Ecology: Principles and applications by J. L. Chapman and M. J. Reiss, Cambridge University Press.
3. Modern statistics for the Life Sciences by A. Grafen and R. Hails, Oxford University Press.
4. An Introduction to Biostatistics by Thomas Glover and Kevin Mitchell, Waveland Pr Inc

LS 507 STRUCTURAL BIOLOGY 3 credits [3-0-0]

A familiarity with the NMR, X-ray, and computational techniques used to study macromolecular structure, motions in macromolecules and the functional importance of dynamics, the basis for various types of macromolecular interactions including protein- protein and protein-nucleic acid interactions, evolutionary relationships of structural features, the determinants of protein structure and an understanding of the current views of protein folding, the chemical basis for interactions with enzyme inhibitors and other ligands. History of Structural Biology: X-ray crystallographic and NMR-structure of Proteins, and Nucleic acids. Proposition of DNA double helical structure in understanding the blue-print of life- Watson & Crick model. Fine structure of Proteins- fibrous, globular and membrane proteins, Nucleosome and Chromatin structure. Cytoskeleton structure and protein-protein Network, Muscle proteins. Structure of Heart, Lung and Brain.

Essential Reading:

4. Textbook of Structural biology by Anders Lilgas, Lars Lilgas, Jui Piskur et al, World Scientific Publisher
5. Advances in structural biology by S. K. Malhotra (Editor), Elsevier.
6. Membrane structural biology by Mary Luckey, Barnes and Noble Publisher.

LS 509 INTRODUCTION TO PROTEOMICS 3 credits [3-0-0]

Definition, classification, and scopes. The emergence of proteome concept: structural and functional proteomes, protein structure related to functional kinetics, e.g. prions, bridging genomics to proteomics. Transcriptomes: measurement of gene expression. Proteome analysis: by methods, 2-D PAGE including protein detection on electro-blot membrane, mass spectrometry and phosphorylation site analysis. Proteomics in relation to animal and plant health and welfare.

Essential Reading:

1. A Textbook of Protein and Proteomics, C Subramanian and Nandan Hazare, Dominant Pub.
2. Discovering Genomics, Proteomics and Bioinformatics (2nd Edition), by A. Malcolm Campbell and Laurie J. Heyer.

LS 511 GENETICS 4 credits [3-1-0]

Introduction to Genetics: Mendelism, Mendel and his experiments, Law of segregation, Law of independent assortment, Application of laws of probability (product rule, sum rule), Chromosomal basis of segregation and independent assortment.
Extensions of Mendelism: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.
Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.
Extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.
Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. Deletion, duplication, inversion, translocation, ploidy and their genetic implications. Homologous and non-homologous recombination including transposition
Evolutionary genetics-Properties and evolution of genetic material flow of genetic information. Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; origin of new genes and proteins; Gene duplication and divergence. Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution.

Essential Reading:

1. Principles of Genetics, E J Gardner, John Wiley & Sons Inc
2. Principles of Genetics, D.P. Snustad & M.J. Simmons, John Wiley and Sons Inc
3. The Science of Genetics, Alan G. Atherly, Jack R. Girton, John F. McDonald, Saunders College Pub

Supplementary Reading:

1. Genetics: From Genes to Genomes by L. Hartwell, Leroy Hood, Michael Goldberg, Ann Reynolds, Lee Silver, Ruth Veres
publisher: McGraw-Hill
2. Medical genetics by Lynn B. Jorde, John C. Carey, Michael J. Bamshad and Raymond L. White.

LS 512 DEVELOPMENTAL BIOLOGY 4 credits [3-1-0]

Basic Concepts of Development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells, Gametogenesis, fertilization and early development: cell surface molecules in sperm-egg recognition

in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, and establishment of symmetry in plants; seed formation and germination.

Cell Aggregation and Differentiation; Axes and pattern formation in Drosophila, 103mmune103r103 and chick; organogenesis, development and regeneration in vertebrates; metamorphosis; environmental regulation of normal development.

Morphogenesis and Organogenesis in Plants: Organization of shoot and root apical meristem; shoot and root development, Programmed cell death, aging and senescence. Embryonic development, cellular differentiation, organogenesis, metamorphosis.

Animal Physiology: Comparative physiology, the respiratory system: Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration, circulatory system: cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation, digestive system: Digestion, absorption, energy balance, BMR, the nervous system: Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture, the excretory system, the endocrine system and reproductive system: Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, neuroendocrine regulation, the skeletal system.

Plant Physiology: Osmoregulation, Solute transport and photoassimilate translocation; Photosynthesis: Light harvesting complexes; mechanisms of electron transport; CO_2 fixation, Respiration and photorespiration: Citric acid cycle, plant mitochondrial electron transport and ATP synthesis, alternate oxidase, photorespiratory pathway; Plant hormones and Sensory photobiology**;** Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses.

Essential Reading:

1. Developmental Biology by S.F. Gilbert, Sinauer Associates Inc.
2. Plant Physiology, Lincoln Taiz and Eduardo Zeiger, Sinauer Associates Inc.

LS 513 ENZYMOLOGY AND METABOLISM 4 credits [3-1-0]

Enzymology: Concept of Enzyme and mechanism of action. Classification of enzumes (OTHLyILi) and nomenclature. Kinetics: derivation of Michaelis-Menten equation, L-B plot, Regulation of enzyme activity, binding site and active site, Factors affecting the rate of enzymatic reaction, Enzyme kinetics for mono- and bi-substrate reactions, Inhibitions –competitive, uncompetitive mixed and non-competitive type, Allosteric regulation, covalent modifications, Isozymes, ribozymes, abzymes. Enzyme inhibition and Mechanisms of inhibitors action

General Metabolism: Biogenetics and ATP, Oxidative and photo phosphorylation; Carbohydrate: Glycolysis, TCA, Gluconeogenesis, Pentose phosphate pathway: Mechanism of selective reactions, Radioisotope distribution study and regulation. Glycogen metabolism: Break down, synthesis, hormonal control and regulation. Amino acids and protein: Catabolism of proteins and amino acids, Urea cycle, Fate of carbon skeleton of amino acids, Mechanism of selective reactions. Biosynthesis of amino acids: Nitrogen fixation, Biosynthesis of essential amino acids, and Mechanism of selective reactions, Regulation. Biomolecules obtained from amino acids. Fatty acids: oxidation (Even, odd, saturated and unsaturated) and Biosynthesis of fatty acids, tri-glycerides, phospholipids and sterols. Regulation of fatty acid metabolism. Introduction, hydrolysis of tri-acylglycerols, α-, β-, 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. Nucleic Acids: Biosynthesis and degradation of purine and pyrimidine, nucleotides, Mechanism of selective reactions and regulation.

Essential Reading:

1. Methods in Enzymology, Academic Press.
2. Biochemistry by Donald Voet, Hardcover: 1616 pages, Publisher: Wiley
3. Lehninger Principles of Biochemistry; David L Nelson; Albert L Lehninger; Michael M Cox; New York : W.H. Freeman

LS 514 FUNDAMENTAL OF GENETICS 3 credits [3-0-0]

Introduction to Genetics: Mendelism, Mendel and his experiments, Law of segregation, Law of independent assortment, Application of laws of probability (product rule, sum rule), Chromosomal basis of segregation and independent assortment, Chi-square test and its application in analysis of genetic data

Extensions of Mendelism: Allelic variation and gene function- Dominance relationships, basis of dominant and recessive mutations, Multiple allelism, allelic series, Testing gene mutations for allelism: complementation test, intragenic complementation, Visible, sterile and lethal mutations, Genotype to phenotype: effect of the environment on phenotype development- Penetrance and expressivity, phenocopy, Gene interactions and modifying genes, Pleiotropy

Sex-linked inheritance, Linkage and crossing over, Genetic recombination and construction of genetic maps in *Drosophila,* Interference and coincidence, Cytological demonstration of crossing over in *Drosophila,* Mitotic recombination, Intragenic recombination, Inheritance of quantitative traits, Continuous and discontinuous variation, Polygenic inheritance, Genetic variance, heritability (narrow sense and broad sense), Cytoplasmic inheritance, maternal effects, inheritance due to parasites and symbionts, Properties and evolution of genetic material, flow of genetic information.

Essential Reading:

1. Principles of Genetics, E J Gardner, John Wiley & Sons Inc
2. Principles of Genetics, D.P. Snustad & M.J. Simmons, John Wiley and Sons Inc

Supplementary Reading:

1. Genetics: From Genes to Genomes by L. Hartwell, Leroy Hood, Michael Goldberg, Ann Reynolds, Lee Silver, Ruth Veres publisher: McGraw-Hill
2. Medical genetics by Lynn B. Jorde, John C. Carey, Michael J. Bamshad and Raymond L. White.

LS 530 AQUATIC BIOLOGY AND MARINE BIOTECHNOLOGY 4 credits [3-1-0]

Unit 1: Aquatic ecosystems

Definition, principles and scope of ecology in relation to aquatic ecosystem. Abiotic and biotic factors. Freshwater ecology- 104mmune-chemical characteristics of freshwater, Marine ecology- 104mmune-chemical characteristics of marine environment, classification, thermal stratification, marine communities. Estuarine and coastal ecology- Characteristics of estuaries, classification, horizontal stratification, estuarine communities, adaptations. Mangrove ecosystems: special features of mangrove habitats and distribution of plants and animals in mangrove ecosystems.

Unit 2: Productivity and benthos

Primary productivity- gross and net productivity; methods employed for measuring productivity; general account of productivity in different oceans. Factors affecting primary production: nutrients, light, temperature, organic micro nutrients and inhibitors, grazing.
Plankton- role in aquatic ecosystem in relation to fisheries; qualitative and quantitative analysis of plankton; eutrophication; red tide; phytoplankton – zooplankton relationships.
Benthos- classification and identification of major types and their role in aquatic production.

Unit 3: Aquatic microbiology and public health

Types of microbes- bacteria, fungi and viruses. Isolation and culture techniques, identification of bacteria and fungi and maintaining their cultures. Methods of studying the marine microorganisms- methods of collection, enumeration (total and viable counts), isolation, culture & identification based on morphological, physiological and biochemical characteristics.
Diseases of cultivable organisms: signs, symptoms, prophylaxis and treatment.
Microbiology of fresh and processed fish; handling of fish- spoilage of fish and shellfish.

Unit- 4: Marine pharmacology
Marine Pharmacology: current status and prospects. Bioactive compounds from marine environment: isolation, purification and identification of compounds.

Unit- 5: Fouling and boring organisms
Biofouling – biofilm, biocorrosion, corrosion process and control of marine structures. Bioinvasion and ballast water. Marine fouling and boring organisms – their biology, adaptation – factors influencing the settlement of macrofoulers.

Unit- 6: Aquaculture and fisheries technology
Application of microbial biotechnology in culture ponds- bioaugmentation, bioremediation for soil and water quality improvement; nutrient cycling; probiotics, prebiotics and immunostimulants.
Tools for disease diagnosis in cultivable organisms – Enzyme 105mmune assays – Dot immunobinding assay – Western blotting – Latex agglutination test – Monoclonal antibodies – DNA based diagnosis.
Reproductive biotechnology- breeding biology and endocrine control of reproduction in fin fishes and shell fishes.
Fish cytogenetics- application of genetics in aquaculture, hybridization of fishes, recent trends and techniques in hybridization, selective breeding, cross breeding, development of disease resistance and high quality new strains, transgenic fish production.
Chromosome manipulation- role in aquaculture, androgenesis, gynogenesis, sex reversal and polyploidy. Cryopreservation.

Essential Reading:

1. Aquatic Ecosystems: Trends and global prospects by Nicholas V. C. Polunin, Cambridge University Press.
2. Handbook of Fish Biology and Fisheries: 2 Volume Set by Paul J. B. Hart, John D. Reynolds, Wiley.
3. Gene Expression and Manipulation in Aquatic Organisms by S. J. Ennion, G. Goldspink, Cambridge University Press
4. Encyclopedia of Aquaculture by Stickney, R.R., John Wiley Sons Inc.

Supplementary Reading:

1. Fundamentals of Aquatic Ecology by R. S. K. Barnes, K. H. Mann, Wiley
2. New developments in marine biotechnology by Y. Le Gal, Y. Le Gal and H. O. Halvorson, Springer US
3. Biochemical aspect of marine pharmacology by P. Lazarovici, Alaken Inc.

LS 531 EPIGENETICS 4 credits [3-1-0]

Epigenesis and development: Concept of epigenetics, Epigenetic mechanisms and regulation of gene expression; DNA-Methylation, Epigenome, Methylome. Histone Code: histone modifications (acetylations, methylations, phosphorylations, sumoylations, uniquitylation etc.) and enzymatic mechanisms. DNA-methyltransferases, Histone acetylases, histone deacetylases, (Histone) protein arginine methyltransferases and demethylases, (Histone) protein lysine methyltransferases and demethylases. Transcriptional silencing by polycomb group proteins and regulation by trithorax group proteins. Histone variants, chromosome inheritance, X-chromosome inactivation. Genomic imprinting, germ line and pluripotent stem cells. Epigenetics of human disese and epigenetic determinants of cancer. Nuclear transplantation and the reprogramming of the genome. RNA interference and regulation of gene expression (RNAi, microRNA, heterochromatin assembly). Position-effect Variegation, heterochromatin formation and gene silencing in Drosophila

Essential Reading:

1. Epigenetics by C. David Allis, Thomas Jenuwein, Danny Reinberg and Marie-Laure Caparros, Cold Spring Harbor Laboratory Press, CSH Press, NY, USA.
2. Epigenetics by Jörg Tost (Editor), Caister Academic Press.

LS 532 MOLECULAR MEDICINE 4 credits [3-1-0]

Overview of Drug Design; Drug targets and vaccine delivery, Cell differentiation, Proliferation and gene expression; junctional components targeted by disease causing micro-organisms; diseases associated with intercellular junctions including multiple sclerosis, type 1 diabetes, inflammatory bowel diseases.

Introduction to Metabolic Disorders; Reproductive disorders, Cardiovascular diseases, Disorders in hormonal action: Insulin dependent and independent diabetes, Importance of intracellular trafficking and its related pathogenesis, Molecular endocrinology in health and disease.

Diseases; Current topics in fungal, parasitic, bacterial and viral diseases; Introduction to metabolic disorders and metabolic profiling; Reproductive disorders; Cardiovascular diseases; Disorders in hormonal action; Insulin dependent and independent diabetes, Molecular endocrinology in health and disease.

Cancer; Basic biology and pathology of cancer, various types of cancers, Molecular epidemiology and genetic susceptibility; Cell proliferation, transformation and cancer progression.

Essential Reading:

1. Molecular Medicine: An Introductory Text by Ronald J. Trent, Elsevier.
2. Science in Medicine: The JCI Textbook of Molecular Medicine American Society for Clinical Investigation

LS 533 MARINE BIOTECHNOLOGY 3 credits [3-0-0]

Unit 1: Aquatic ecosystems
Definition, principles and scope of ecology in relation to aquatic ecosystem. Abiotic and biotic factors. Freshwater ecology- Physico-chemical characteristics of freshwater, Marine ecology- Physico-chemical characteristics of marine environment, classification, thermal stratification, marine

communities. Estuarine and coastal ecology- Characteristics of estuaries, classification, horizontal stratification, estuarine communities, adaptations.

Unit 2: Productivity and benthos

Primary productivity, gross and net productivity. Plankton and their role in aquatic ecosystem in relation to fisheries; qualitative and quantitative analysis of plankton. Biomass , food webs, energy flow. Benthos- classification and identification of major types and their role in aquatic production. Methods of collection, preservation and identification of dominant types from different water habitats.

Unit 3: Aquatic microbiology and public health

Types of microbes, bacteria, fungi and viruses. Isolation and culture techniques, identification of bacteria and fungi and maintaining their cultures. Methods of studying the marine microorganisms-methods of collection, enumeration (total and viable counts), isolation, culture & identification based on morphological, physiological and biochemical characteristics. Microbiology in relation to fish and prawn production. Biological factors of water-self purification. Technical means of controlling microbial population in water.

Unit- 4: Marine pharmacology

Marine Pharmacology: Prospects – Bioactive compounds from marine environment: isolation, purification and identification of compounds.

Unit- 5: Fouling and boring organisms

Biofouling – Biofilm formation. Marine fouling and boring organisms – their biology, adaptation – Factors influencing the settlement of macrofoulers. Antifouling and Anti boring treatments. Corrosion Process and control of marine structures.

Unit- 6: Aquaculture and fisheries

Application of microbial biotechnology in culture ponds, bioaugmentation, bioremediation for soil and water quality improvement – nutrient cycling, bio-fertilization. Probiotics – Immunostimulants. Regulation of bacterial growth.

Tools for disease diagnosis in cultivable organisms – Enzyme 107mmune assays – Dot immunobinding assay – Western blotting – Latex agglutination test – Monoclonal antibodies – DNA based diagnosis.

Hybridization of fishes, recent trends and techniques in hybridization, selective breeding, cross breeding, development of disease resistance and high quality of new strains, transgenic fish production. Chromosome manipulation, its role in aquaculture, androgenesis, gynogenesis, sex reversal and tripoidy. Cryopreservation.

Essential Reading:

1. Aquatic Ecosystems: Trends and global prospects by Nicholas V. C. Polunin, Cambridge University Press.
2. Handbook of Fish Biology and Fisheries: 2 Volume Set by Paul J. B. Hart, John D. Reynolds, Wiley.
3. Gene Expression and Manipulation in Aquatic Organisms by S. J. Ennion, G. Goldspink, Cambridge University Press
4. Encyclopedia of Aquaculture by Stickney, R.R., John Wiley Sons Inc.

Supplementary Reading:

1. Fundamentals of Aquatic Ecology by R. S. K. Barnes, K. H. Mann, Wiley
2. New developments in marine biotechnology by Y. Le Gal, Y. Le Gal and H. O. Halvorson, Springer US
3. Biochemical aspect of marine pharmacology by P. Lazarovici, Alaken Inc.

LS 534 INTRODUCTION TO EPIGENETICS 3 credits [3-0-0]

Epigenesis and development, Concept of epigenetics, Epigenetic mechanisms and regulation of gene expression; DNA-Methylation, Epigenome, Methylome. Histone Code: histone modifications (acetylations, methylations, phosphorylations, sumoylations, uniquitylation etc.) and enzymatic mechanisms. DNA-methyltransferases, Histone acetylases, histone deacetylases, (Histone) protein arginine methyltransferases and demethylases, (Histone) protein lysine methyltransferases and demethylases. RNA interference and regulation of gene expression (RNAi, microRNA ETC)

Essential Reading:

1. Epigenetics by C. David Allis, Thomas Jenuwein, Danny Reinberg and Marie-Laure Caparros, Amazon Publishers.
2. Epigenetics by Jörg Tost (Editor), Caister Academic Press.

LS 535 BASICS IN MOLECULAR MEDICINE 3 credits [3-0-0]

Principles of protein and nucleic acid structure.Overview of drug design and drug targets. Molecular 108mmune108r in drug discovery. Computer representations of Molecules, chemical databases, cell differentiation, proliferation and gene expression; junctional components targeted by disease causing micro-organisms; diseases associated with intercellular junctions including multiple sclerosis, type 1 diabetes, inflammatory bowel disease, and cancers of the breast, prostate and colon.

Introduction to metabolic disorders and metabolic profiling. Reproductive disorders. Cardiovascular diseases. Disorders in hormonal action. Insulin dependent and independent diabetes. Ligand induced 108mmune108r108 and gene expression in eukaryotic cells. Importance of intracellular trafficking and its related pathogenesis. Molecular endocrinology in health and disease. Cancer and cell cycle.

Current topics in fungal, parasitic, bacterial and viral 108mmune108.Introduction to metabolic disorders and metabolic profiling. Reproductive disorders. Cardiovascular diseases. Disorders in hormonal action. Insulin dependent and independent diabetes. Ligand induced 108mmune108r108 and gene expression in eukaryotic cells. Importance of intracellular trafficking and its related pathogenesis. Molecular endocrinology in health and disease. Cancer and cell cycle.Basic biology and pathology of cancer, multifactorial etiology of cancer. Molecular epidemiology and genetic susceptibility. Cell proliferation, transformation and cancer progression.

Essential Reading:

1. Molecular Medicine: An Introductory Text by Ronald J. Trent, Elsevier.
2. Science in Medicine: The JCI Textbook of Molecular Medicine American Society for Clinical Investigation.

LS 536 RNAi, STEM CELLS AND ONCOGENOMICS 4 credits [3-1-0]

1. Concept of RNA interference (RNAi), different types of regulatory RNA viz. miRNA, piRNA, lncRNA, rasiRNA etc and their basics, biogenesis and regulatory roles.
2. What are Stem cells, Different types of stem cells (hESC, iPSC, mESC etc) and their role in tissue regeneration
3. Role of RNAi in stem cell induction
4. What is oncogenomics? How is it influenced by Cancer Stem Cells (CSCs)?
5. The stem cell properties influenced by these regulatory RNAs.
6. Role of regulatory RNAs in CSCs and hence its role in oncogenomics
7. Current research progress in regenerative therapy by stem cells (overview on current research findings, their significance and challenges)

Essential Reading:

1. Regulatory RNAs: Basics, Methods and Applications. B. Mallick and Z. Ghosh, Springer-Verlag, Heidelberg, Germany

LS 537 PROCESSING OF FOOD COMMODITIES 3 credits [3-0-0]

Objectives:

1) To study the processing methods for different food materials like fruits & Vegetables, dairy products, cereals, meat, poultry, fish and bakery products
2) To study different innovative food processing techniques

Outcomes:

1) Students will acquire knowledge on the basics of food processing
2) Students will have a know-how on the various processing technologies involving fruits and vegetables, dairy, cereals, meat, fish, egg and plantation products
3) Students to acquire basic knowledge on microbiology of food products
4) Students will have an overview of the possible arena of entrepreneurial activity related to food products.

Unit I Fruits and vegetable processing

Production of Fruits and vegetables in India, Cause for heavy losses, preservation treatments – Basics of Canning, Minimal processing and Hurdle technology as applied to Vegetable and Fruit processing, Processing of fruit juices, Dehydration, Aseptic processing

Unit II Cereal, Pulses and Oil seeds Technology

Rice milling, Pulse milling, Wheat milling – Oil extraction – Methods of manufacture of Bread – different processes of manufacture – types of breads – buns, biscuits, cakes and cookies –Pasta products

Unit III Dairy processing

Basic dairy terminology, composition, General tests at reception, Dairy Processing – Method of manufacture of Standardised, toned and double toned milk, milk powder – Method of manufacture of dairy products – Icecream, Cheese, Paneer, Yoghurt - Pasteurisation and microorganisms involved in spoilage of milk.

U**nit IV Meat, Fish and Poultry processing**

Meat composition from different sources, Definitions and measurements, Carcass Processing, Meat Products, Processing of Poultry Products and Fish.

Unit V Plantation product technology

Processing of Tea, Coffee and Cocoa – Outline of the methods of manufacture of – green tea, black tea, instant tea, Instant coffee, Cocoa and Chocolate. Outline of the methods of processing of Pepper, cardamom, ginger, vanilla and turmeric.

Essential Reading:

1. Srivastava, R.P. and Kumar, S.: Fruit and Vegetable Preservation: Principles and Practices. International Book Distributing Co. Lucknow (2nd Edition 1998).
2. Chakraverty, A., Mujumdar A.S., Raghavan G.S.V and Ramaswamy H.S. Handbook of Post-harvest Technology: Marcel Dekker Press, USA (2001)

3. Sukumar De. 2006. Outlines of Dairy Technology. Oxford University Press, New Delhi

LS 538 MAN AND MICROBES 3 credits [3-0-0]

Objectives:

1) To study the basic concepts of microorganisms
2) To study the utilization of microorganisms in various sectors

Outcomes:

1) Students to acquire knowledge on the basics of microbiology
2) Students will have know-how on the various uses of microorganisms.
3) Students to acquire basic knowledge on microbiology of food products
4) Students will have an overview of the possible arena of entrepreneurial activity related to microbiology.

Syllabus

Unit I: Basics of microorganisms

Classification of microorganisms, shape and arrangement, structure and function of internal organelles.

Unit II: Microbes in Food and agriculture

Fermented foods, food spoilage and food borne diseases. Role of microbes in different biogeochemical cycles, biofertilizers and biopesticides.

Unit III: Microbes in medicines

Concept of pathogenesis, microbial prophylactic and therapeutic agents.

Unit IV: Microbes in bioenergy and war

Role of microbes in bioenergy production. Anthrax bacillus, *Clostridium botulinum* and aflatoxins

Unit V: Microbes in disposal and cleaning up

Role of microbes in waste water treatment, biodegradation and bioremediation

Suggested Reading:

1. John Postgate. 2000. Microbes and Man. Cambridge University Press.
2. Willey, Sherwood and Woolverton. 2008. Prescott, Harley, and Klein's Microbiology. McGraw-Hill International Edition. 7th Edition. Singapore.
3. Pommerville, J.C. 2006. Alcamo's Fundamentals of Microbiology. Jones and Bartlett International Edition. USA.

LS 539 STEM CELL AND REGENERATIVE MEDICINE 3 credits [3-0-0]

Concept of stem cells; types of stem cells, totipotent and pluripotent stem cells; Embyronic stem cells, Natural fertilization vs in-vitro fertilization and development of embryonic stem cells (ESCs); molecular and genetic control of cell fate specification and differentiation; origins of totipotent and pluripotent stem cells, sources of ESCs, ethical issues associated with embryonic stem cells, cells responsible for regeneration; differences between wound healing and regeneration; Adult stem cells and their location in the body; role of adult stem cells in homeostasis; comparison between embryonic and adult stem cells; Cell fate and 110mmune110r; Microenvironment, how cell phenotype comes from genotype; transcription and translation; how a cell knows what to become; Developing pluripotent stem cells; hematopoietic stem cell and its descendents: myeloid, erythroid and lymphoid lineages; Reprogramming of Somatic Cells to induced pluripotent stem cells (IPSCs); role of transcription factors in pluripotency, efficacy, safety of IPSCs; Application of iPS technology to Regenerative Medicine.

Essential Reading:

1. Stem Cells: A Very Short Introduction; Jonathan Slack; Oxford University Press (2012)
2. Stem Cells; Eapen Cherian, G. Nandhini, Anil Kurian; Jaypee Brothers Medical Pub (2011)
3. Regulatory RNAs: Basics, Methods & Applications; B. Mallick & Z. Ghosh; Springer-Verlag (2012)

LS 540 RESEARCH METHODOLOGY 3 credits [3-0-0]

Bio-Statistics

Unit 1: Collection and presentation of data
Statistics- definition, function, scope and limitations. Collection of biological data – sampling, aim, techniques, random sampling and non-random sampling. Classification of data- frequency distribution and tabulation. Tabulation of data and graphical representation- bar diagram, pie diagram, frequency curve, histogram, Ogive.

Unit 2: Statistics of location and dispersion
Measures of central value- Mean, Median, Mode. Measures of dispersion- standard deviation, standard error, coefficient of variation. Normal distribution, Skewness and Kurtosis.

Unit 3: Sampling statistics and testing of hypothesis
Sampling distribution, Sampling error, standard errors, degrees of freedom. Test of significance based on large samples- procedure for testing hypothesis.

Unit 4: Correlation and regression
Use of correlation in biological science – purpose, positive correlation, negative correlation, calculating correlation coefficient, significance, other types of correlation. Use of Regression in Biological Sciences – purpose, regression coefficient Y, Regression line.

Unit 5: 't' test, Chi square and ANOVA
Student 't' test for mean, Chi-square test, Analysis of variance- One-way and Two-way ANOVA.

Unit 6: Use of computers in Bio-statistics
Use of computer in Bio-Statistics- Computation of Median, Variance, Standard Deviation, and Correlation Coefficient etc. Application of statistical packages- MS Excel, SPSS etc.

Bio-Instrumentation

Unit 1: Chromatography
Paper, TLC, gel filtration, ion-exchange chromatography, affinity chromatography, HPLC and GLC

Unit 2: Microscopy
Optical microscopy, Bright field, Dark field, phase contrast and fluorescence microscopy. Electron microscopy: Transmission and scanning electron microscopy.

Unit 3: Centrifugation
Principle of centrifugation, rotors, different types of centrifuges, preparative and analytical centrifugation, ultra centrifugation

Unit 4: Electrophoresis
Gel electrophoresis, SDS-PAGE, isoelectric focusing, two-dimensional electrophoresis, 111mmune electrophoresis, capillary electrophoresis

Unit 5: Spectroscopy
Atomic Absorption spectrophotometry, Mass spectrometry, NMR.

Essential Reading:

1. Fundamentals of statistics by S.C. Gupta, Himalaya Publishing House
2. Biostatistical analysis by J. H. Zar, Prentice Hall.

3. Principles of Biochemistry and molecular biology by K. Wilson and J. Walker, Cambridge University Press.
4. Principles of Instrumental analysis by D. A. Skoog and J. J. Leary, Saunders College Publishing, Philadelphia

Supplementary Reading:

7. Modern statistics for the Life Sciences by A. Grafen and R. Hails, Oxford University Press
8. An Introduction to Biostatistics by Thomas Glover and Kevin Mitchell, Waveland Pr Inc

LS 542 BASIC BIOTECHNOLOGY 3 credits [3-0-0]

Definition and scope of biotechnology; branches of biotechnology; Bioprocess technology for the production of cell biomass and primary/secondary metabolites, such as baker's yeast, ethanol, citric acid, amino acids, exopolysacharides, antibiotics and pigments etc; Regeneration of plants and totipotency; Plant products of industrial importance; Biochemistry of major metabolic pathways and products; Autotrophic and heterotrophic growth; Plant growth regulators and elicitors; Cell suspension culture development; Production of secondary metabolites by plant suspension cultures; Hairy root cultures and their cultivation; generation of transgencies and their application in agriculture; Cloning in animals; Genetic engineering; transgenic animals; Animal cell preservation; Genomics and its application to health and agriculture, including gene therapy

Essential Reading:

1. Introduction to Biotechnology (2nd Edition); William J. Thieman and Michael A. Palladino; Benjamin Cummings (2008).
2. Introduction to Plant Biotechnology; H.S. Chawla; Science Publishers, 2002

LS 575 APPLIED BIOINFORMATICS LABORATORY 2 credits [0-0-3]

Visualizing and understanding biological data formats, such as genbank flat file, genpept, fasta, nexus, pdb etc.
Exploring nucleotide and protein databases: GenBank, EMBL, DDBJ, PIR-PSD, SwissProt, TrEMBL/GenPept.
Visualizing and understanding 3D structure of macromolecules by molecular viewers: RasMol, Cn3D, Swiss-PDB Viewer
Sequence comparisons & alignment
Estimating protein secondary structure and physical attributes: Proteolytic digestion mapping, molecular weight and amino acid composition determination, isoelectric point estimation, hydrophobicity and hydrophobic moment determinations, surface probability and antigenicity mapping, and secondary structure prediction.
Introduction to molecular phylogenetics: Clustering techniques, Hierarchial & non-hierarchial, Bootstrapping, Interpretation of phylogenetic trees.
Comparative genomics and gene prediction
Pattern matching
Designing of primers for PCR; Identification of restriction enzyme maps for molecular biology applications and other genomics and proteomics analysis tools embedded in the Genomics Workbench
Prediction of secondary & tertiary structure of proteins
Immunoinformatics concepts and tools
Structural bioinformatics (Homology modeling)
Molecular docking and Drug design
Vaccine design
Exploring EMBOSS series, NCBI tools and other tools

Essential Reading:

Bioinformatics: Principles and Applications by Z. Ghosh and B. Mallick, Oxford University Press.

LS 581 CANCER BIOLOGY 4 credits [3-1-0]

Introduction to mammalian cell culture and applications; what is Cancer? Profile of a Cancer Cell; How Cancers Spread; Identifying the causes of Cancer: Chemicals and Cancer , Radiation and Cancer , Infectious Agents and Cancer, Heredity and Cancer; Oncogenes, Tumor Suppressor Genes and Cancer Overview; Chromosome heterogeneity, micro satellite instability, Epigenetic basis of cancer, DNA-methylation and histone modifications associate to cancer; Cancer stem cell: identification, property and therapeutic implication; tumor evolution, escape from non-immune and immune surveillance. Immunoediting, role of immunological ignorance and tolerance in tumor escape, Regulatory lymphocytes in cancer; Cancer Screening, Diagnosis, and Treatment; Preventing Cancer.

Essential Reading:

1. Principles of Cancer Biology: International Edition; Lewis J. Kleinsmith, Pearson Higher Education
2. Cancer Stem Cells: Identification and Targets, Sharmila A. Bapat, Wiley
3. Cancer immunotherapy: immune suppression and tumor growth , George C. Prendergast and Elizabeth M. Jaffee, Academic Press

DEPARTMENT OF MATHEMATICS

DETAILED SYLLABI OF COURSES

Sub. Code	Subject	L-T-P	Credits
MA 101	Differential Equations	3-1-0	4
MA 102	Matrix theory, Vector Calculus and Fourier Analysis	3-1-0	4
MA 201	Probability, Statistics and Numerical Methods	3-1-0	4
MA 202	Complex Analysis and Partial Differential Equations	3-1-0	4
MA 205	Calculus	3-1-0	4
MA 206	Introduction to Complex Analysis and PDEs	3-1-0	4
MA 207	Introduction to Numerical Analysis	3-1-0	4
MA 208	Analysis-I	3-1-0	4
MA 270	Numerical Methods Laboratory	0-0-3	2
MA 301	Group Theory	3-1-0	4
MA 311	Linear Algebra	3-0-0	3
MA 312	Real Analysis	3-0-0	3
MA 313	Complex Analysis and Transform Techniques	3-0-0	3
MA 321	Discrete Mathematics	3-1-0	4
MA 322	Linear Programming	3-1-0	4
MA 332	Probability	3-1-0	4
MA 372	Statistics Laboratory	0-0-3	2
MA 373	Laboratory Works on Latex, and Matlab	0-0-3	2
MA 401	Real Analysis	3-1-0	4
MA 402	Measure Theory	3-1-0	4
MA 403	Linear Algebra	3-1-0	4
MA 404	Functions of a Complex Variable	3-1-0	4
MA 405	Partial Differential Equations	3-1-0	4
MA 407	Topology	3-1-0	4
MA 413	Analysis-II	3-1-0	4
MA 423	Discrete Mathematics	3-0-0	3
MA 424	Operations Research	3-0-0	3
MA 426	Elementary Stochastic Processes with Applications	3-0-0	3
MA 431	Mathematical Methods	3-0-0	3
MA 432	Finite Difference Methods	3-0-0	3
MA 433	Finite Element Methods	3-0-0	3
MA 438	Dynamical Systems	3-1-0	4
MA 470	Laboratory works on Real Life Problems – I	0-0-3	2
MA 471	Object Oriented Programming Practice Laboratory	0-0-3	2
MA 472	Research Paper Review	0-0-3	2
MA 481	Departmental Seminar – I	0-0-3	2
MA 482	Departmental Seminar – II	0-0-3	2
MA 501	Abstract Algebra	3-1-0	4
MA 502	Functional Analysis	3-1-0	4
MA 503	Theory of Rings and Fields	3-1-0	4
MA 504	Introduction to Several Complex Variables	3-1-0	4
MA 510	Calculus of Several Variables	3-1-0	4
MA 511	Differential Geometry	3-1-0	4
MA 512	Fourier Analysis	3-1-0	4
MA 513	Differential Topology	3-1-0	4
MA 514	Rings and Modules	3-1-0	4
MA 515	Homotopy Theory	3-1-0	4

MA 516	Operator Theory	3-1-0	4
MA 517	Lie Algebra	3-1-0	4
MA 518	Advanced Complex Analysis	3-1-0	4
MA 519	Multi-Linear Algebra	3-1-0	4
MA 520	Automata Theory	3-1-0	4
MA 521	Combinatorics	3-1-0	4
MA 522	Operations Research	3-1-0	4
MA 523	Discrete Mathematics	3-1-0	4
MA 524	Statistical Methods	3-1-0	4
MA 525	Elementary Stochastic Processes with Applications	3-1-0	4
MA 527	Fractuals	3-1-0	4
MA 529	Information Theory	3-1-0	4
MA 531	Boundary Layer Theory	3-1-0	4
MA 532	Numerical Solutions of Partial Differential Equations	3-1-0	4
MA 534	Geometry of Robotics	3-1-0	4
MA 540	Singular Homology Theory	3-1-0	4
MA 542	Tensor Analysis	3-1-0	4
MA 544	Category Theory	3-1-0	4
MA 546	Differentiable Manifolds	3-1-0	4
MA 548	Field Theory	3-1-0	4
MA 549	Algebraic Geometry	3-1-0	4
MA 550	Coding Theory	3-1-0	4
MA 551	Numerical Analysis	3-1-0	4
MA 552	Fuzzy Logic and Set Theory	3-1-0	4
MA 553	Optimization Techniques	3-1-0	4
MA 554	Graph Theory with Algorithms	3-1-0	4
MA 555	Stochastic Processes	3-1-0	4
MA 556	Number Theory	3-1-0	4
MA 558	Sampling Techniques	3-1-0	4
MA 560	Mathematical Methods	3-1-0	4
MA 561	Lie Groups & Applications to ODEs & PDEs	3-1-0	4
MA 562	Finite Volume Methods for Hyperbolic PDEs	3-1-0	4
MA 563	Wavelets and Applications	3-1-0	4
MA 564	Integral Transforms	3-1-0	4
MA 565	Fractional Order Calculus	3-1-0	4
MA 566	Fractional Differential Equations and Fractional Order Models	3-1-0	4
MA 567	Theory of Vibrations	3-1-0	4
MA 568	Mathematics of Soft Computing	3-1-0	4
MA 569	Perturbation Methods	3-1-0	4
MA 571	Statistical Methods Laboratory	0-0-3	2
MA 572	Laboratory Works on Real Life Problems – II	0-0-3	2
MA 574	Laboratory Works on NSPDE	0-0-3	2
MA 591	Research Project – I	0-0-6	4
MA 592	Research Project – II	0-0-9	6
MA 593	Seminar & Technical Writing – I	0-0-3	2
MA 594	Seminar & Technical Writing – II	0-0-3	2
MA 595	Short term Industrial/Research Experience	0-0-3	2
MA 596	Comprehensive Viva Voce	0-0-3	2

MA 101 DIFFERENTIAL EQUATIONS 4 credits [3-1-0]

Differential equations*:** First-order differential equations: Basic concepts and ideas, Separable equations, Exact equations, Integrating factors, Linear differential equations, Bernoulli equation, Orthogonal trajectories of curves. Applications to physical problems, Linear differential equations of second and higher order: Homogeneous linear equations of second order, Euler-Cauchy equation, Solution by undermined coefficients and variation of parameters, Higher order linear differential equations. Applications to physical problems. ***Series solutions of differential equations and special functions*:** Power series method, Legendre's equations and functions, Frobenius method, Bessel's equation and functions, Sturm-Liouville problems, Orthogonal functions, Orthogonal eigen-function expansions, Applications to physical problems. ***Laplace transforms: Laplace transform, Inverse Laplace transforms, Solution of differential equations, Differentiation and integration of transforms, Integral equations.

Essential Reading:

1. E. Kreyszig, *Advanced Engineering Mathematics*, Wiley India Pvt. Ltd. 2007 Chapters: Chapter 1 (excluding 1.9), 2, 3, 4, 5.

MA 102 MATRIX THEORY, VECTOR CALCULUS AND FOURIER ANALYSIS 4 credits [3-1-0]

***Matrix theory*:** Linear Systems and equations, Gauss elimination, Rank of a matrix, Linear independence, Vector space, Solutions of linear systems, Existence, uniqueness, Cramer's rule, Inverse of a matrix, Gauss-Jordon elimination, Vector spaces, Inner product spaces, Linear transformations. Eigen values, Eigen vectors, Symmetric, skew-symmetric and orthogonal matrices, Complex matrices: Hermitian, skew- Hermitian, and unitary matrices, Similarities of matrices, Basis of eigenvector, Diagonalisation ; ***Vector calculus*:** Vector differential calculus: Grad, div, curl, Vector algebra in 2-space and 3-space, Inner product (dot product), Vector product (cross product), Vector and scalar functions and fields, Derivatives, Curves, tangents are length, Velocity and acceleration, Curvature and torsion of a curve, Gradient of a scalar field, Directional derivative, Divergence of a vector field, Curl of a vector field. Vector integral calculus: Line integrals, Line integral independent of path, Double Integrals, Green's theorem in the plane, Surfaces and surface integrals, Triple integrals: Divergence theorem of Gauss, Further applications of the divergent theorem, Stoke's theorem ; ***Fourier Analysis*:** Fourier series, Integrals and transforms: Fourier series, Functions of any period $p = 2L$, Even and odd functions: Half-range expansions, Complex Fourier series, Forced oscillations, Approximation by trigonometric polynomials, Fourier integrals, Fourier cosine and sine transforms, Fourier transform.

Essential Reading:

1. E. Kreyszig *Advanced Engineering Mathematics*, Wiley India Pvt. Ltd. 2007 Chapters : 6 (6.3 – 6.8), 7, 8, 9, and 10.

MA 201 PROBABILITY, STATISTICS AND NUMERICAL METHODS 4 credits [3-1-0]

***Probability and Statistics*:** Probability theory: Probability, Random variables, Probability distributions, Mean and variance of distributions, Binomial, Poisson and Hyper-geometric distributions, Normal distribution, Distributions of several random variables, Mathematical statistics, Random sampling, Estimation of parameters, Confidence intervals, Testing of hypothesis, Decisions, Quality control, Acceptance sampling, χ^2-test for goodness of fit, Nonparametric tests, Regression analysis, Fitting of straight lines, Correlation analysis. ***Numerical Methods*:** Numerical methods in general: Floating point, Round-off, error, Propagation of error, Interpolation, Splines, Numerical integration and differentiation. Numerical methods in linear algebra: Gauss elimination, LU-Factorization, Matrix inversion, Linear systems: Solution by iteration, Linear systems: Ill-conditioning, Norms, Method of least squares, Matrix eigen value problems, Inclusion of matrix eigen values, Eigen values by iteration (Power method), Tridiagonalization and QR-factorization, Numerical methods for differential equations: Methods for first-order differential equations, Multistep

methods, Methods for systems and higher order equations, Methods for elliptic partial differential equations, Methods for parabolic and hyperbolic equations.

Essential Reading:

1. E. Kreyszig, *Advanced Engineering Mathematics*, Wiley India Pvt. Ltd. 2007Chapters: 17, 18,19, 22 (excluding 22.4), 23.

MA 202 COMPLEX ANALYSIS AND PARTIAL DIFFERENTIAL EQUATIONS 4 credits [3-1-0]

***Complex Analysis*:** Derivative. Analytic function, Cauchy Riemann equations, Laplace's equation, Geometry of analytic functions, Exponential function, Trigonometric functions, Hyperbolic functions, Logarithm, General power, Conformal mapping, Linear fractional transformations. Complex integration, Line integral in the complex plane, Cauchy's Integral Theorem, Cauchy's Integral Formula, Derivative of Analytic functions, Power series, Taylor series, Sequences, Series, Convergence tests, Functions Given by power series, Taylor series and Maclaurin series, Uniform convergence. Laurent series, Residue integration, Laurent series, Singularities and zeros infinity, Residue integration methods, Evaluation of real integrals. ***Partial Differential Equations*:** Basic concepts, Modeling of vibrating string, Wave equation, Separation of variable, Use of Fourier series, D'Alembert's solution of the wave equation, Heat equation, Solution by Fourier Series, Solution by Fourier integral and transforms, Modeling: Membrane, Two-dimensional wave equation, Rectangular membrane. Use of double Fourier series, Laplacian in polar coordinates, Circular membrane, Use of Fourier–Bessel series, Laplace's equation in cylindrical and spherical coordinates, Potential, Solution by Laplace transforms.

Essential Reading:

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, Wiley India Pvt. Ltd. 2007
   Chapters: 11, 12 (12.3 – 12.9), 13,14, 15.

MA 205 CALCULUS 4 credits [3-1-0]

Real numbers, Real sequences, Convergence of sequences and series of real numbers, Limits, Continuity of functions, Differentiability, Rolle's theorem, Mean value theorem, Taylor's theorem, Maxima, Minima, Points of inflection, Asymptotes and curvature, Definite integral as limit of a sum, Properties of definite integrals, Application of definite integrals, Power series, Test of convergence, Alternating series, Absolute convergence, Partial derivatives, Gradient and directional derivatives, Chain rule, Lagrange multipliers.

Essential Reading:

1. G.B. Thomas and R.L. Finney, *Calculus and Analytical Geometry (9^{th} Edition),* ISE Reprint, Addison-Wesley, 1998.

Supplementary Reading:

1. N. Piskunov, *Differential and Integral Calculus*, GK Publishers, 1996.

MA 206 INTRODUCTION TO COMPLEX ANALYSIS AND PDES 4 credits [3-1-0]

***Complex Analysis*:** Derivative. Analytic function, Cauchy Riemann equations, Laplace's equation, Geometry of analytic functions, Exponential function, Trigonometric functions, Hyperbolic functions, Logarithm, General power, Conformal mapping, Linear fractional transformations. Complex integration, Line integral in the complex plane, Cauchy's Integral Theorem, Cauchy's Integral Formula, Derivative of Analytic functions, Power series, Taylor series, Sequences, Series, Convergence tests, Functions Given by power series, Taylor series and Maclaurin series, Uniform

convergence. Laurent series, Residue integration, Laurent series, Singularities and zeros infinity, Residue integration methods, Evaluation of real integrals.

***Partial Differential Equations*:** Classification of integrals, Linear equations of PDEs, Charpits method, Jacobi method, Method of Characteristics, Quasi linear PDEs, Nonlinear first order PDEs, Classification of second order PDEs, Methods for Wave equation, Heat equation and Laplace equation

Essential Reading:

1. R. V. Churchil and Brown**, Complex variables and applications, Tata McGraw Hill, 1990.**
2. T. Amaranath, An Elementary course in Partial Differential Equations, Narosa, 2009.

MA 207 INTRODUCTION TO NUMERICAL ANALYSIS 4 credits [3-1-0]

Definition and sources of errors, Propagation of errors, Backward error analysis, Sensitivity and conditioning, Stability and accuracy, Floating-point arithmetic and rounding errors. Nonlinear equations, Bisection method, Newton's method and its variants, Fixed point iterations, Convergence analysis. Newton's method for non-linear systems. Finite differences, Polynomial interpolation, Hermite interpolation, Spline interpolation, B-splines. Numerical integration, Trapezoidal and Simpson's rules, Newton-Cotes formula, Gaussian quadrature, Richardson Extrapolation IVP: Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, Multistep methods, Predictor-Corrector method Accuracy and stability,

Essential Reading:

1. S. D. Conte and Carl de Boor, *Elementary Numerical Analysis - An Algorithmic Approach, 3rd Edition*, McGraw Hill, 1980.

Supplementary Reading:

1. K. E. Atkinson, *Introduction to Numerical Analysis*, 2nd Edition, John Wiley, 1989.

MA 208 ANALYSIS -I 4 credits [3-1-0]

Metric spaces: Open sets, Closed sets, Continuous functions, Completeness, Cantor intersection theorem, Baire category theorem, Compactness, Totally boundedness, Finite intersection property.

Functions of several variables: Differentiation, inverse and implicit function theorems. Rlemann-Stieitjes integral: Definition and existence of the integral, Properties of the integral, Differentiation and integration.

Sequence and Series of functions: Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation. Equicontinuity, Ascoli's Theorem.

Essential Reading:

1. W.Rudin, *Principles of Mathematical Analysis*, McGraw-Hill, 1986.
2. H.L. Royden, *Real Analysis*, Macmillan, 1988.

MA 270 NUMERICAL METHODS LABORATORY 2 credits [0-0-3]

Experiments to be handled using FORTRAN/C ++/JAVA

1. Bisection Method
2. Method of false position and secant method
3. Newton-Raphson method

4. Method of successive approximation
5. Gaussian elimination method
6. Gauss-Seidel iterative method
7. Inversion of a matrix
8. Eigen values and eigen vectors
9. Lagrange's interpolation
10. Newton's forward and backward interpolation
11. Everette's formula
12. Numerical differentiation
13. Trapezoidal rule of integration
14. Simpson's one-third rule
15. Simpson's three-eighth rule
16. Euler's method
17. Improved Euler's method
18. Runge-Kutta second and fourth order methods
19. Predictor-corrector methods
20. Taylor series method

MA 301 GROUP THEORY 4 credits [3-1-0]

Groups, Subgroups, Centralizers, Normalizers, Stabilizers, Kernels, Cyclic groups, Subgroups generated by a subset of a group, Quotient groups, Lagrange's theorem, Homomorphisms, Isomorphism theorems, Composition series, Solvable groups, Nilpotent groups, Symmetric group, Alternating group, Group actions, Permutation representations, Automorphisms, p-groups, The Sylow theorems, Simplicity of the Alternating group, Direct products of groups, Fundamental theorem of finitely generated abelian groups, Groups of small orders, Rings, Ring homomorphisms, Ideals, Ring of fractions, The Chinese remainder theorem, Euclidean domains, Principal domains, Unique factorization domains, Matrix rings, Polynomial rings, Irreducible Criteria, Eisenstein's criterion.

Essential Reading:

1. D. S. Dummit & R. M. Footee, *Abstract Algebra*, Wiley, 2008

Supplementary Reading :

1. N. Herstien, *Topics in Algebra*, Wiley, 2008
2. J. J. Rotman, *An Introduction to the Theory of Groups*, Springer, 1999.

MA 311 LINEAR ALGEBRA 3 credits [3-0-0]

Vector spaces, Bases and dimensions, Change of bases and change of coordinates, Sums and direct sums, Quotient spaces. Linear transformations, Representation of linear transformations by matrices, Dual spaces, Invariant subspaces, Direct-sum decomposition, Cyclic subspaces and Annihilators, The minimal polynomial, The rational and Jordan canonical forms, Inner product spaces, Orthonormal bases, Gram-Schmidt process. Adjoint operators, Normal, unitary, and self-adjoint operators, Spectral theorem for normal operators.

Essential Reading:

1. K. Hoffman and R. Kunze, *Linear Algebra*, Prentice Hall of India, 1996.

Supplementary Reading:

1. G. Schay, *Introduction to Linear Algebra* , Narosa, 1997.
2. G. C. Cullen, *Linear Algebra with Applications*, Addison Wesley, 1997.

MA 312 REAL ANALYSIS 3 credits [3-0-0]

The real number system : Elementary logic, The field axioms, the axiom of order, geometric representation of real numbers.

Metric sets and limits : Metric sets, Interior points and boundary points of a set, open sets and closed sets, limit point of a set, sequences, monotonic sequences, Cauchy sequences, limit of a function.

Continuity and Differentiation: Continuous functions, uniform continuity, mean value theorem for derivatives, the total differential, the directional derivative.

Integration : Step functions, upper and lower integral of a bounded function, integral of a bounded function, interchange of limits, the fundamental theorem of differential and integral calculus.

Essential Reading :

1. J.M. Howie, *A First Course in Real Analysis*, Springer, 2001

MA 313 COMPLEX ANALYSIS AND TRANSFORM TECHNIQUES 3 credits [3-0-0]

Analytic functions, Line integral, Cauchy's integral theorem and integral formula, Taylor and Laurent series, Residue theorem and applications, Bilinear transformations, Fourier transformations , Fourier transforms (exp, sin, cos), Laplace transforms , Inversion integrals, Convolution, Applications.

Essential Reading:

1 R. V. Churchil and Brown**, Complex variables and applications, Tata McGraw Hill, 1990.**

Supplementary Reading:

1 Erwin Kreyszig, *Advanced Engineering Mathematics*, Wiley India Pvt. Ltd. 2007.

2 I.N. Sneddon, The use of integral transforms, Tata MCGraw Hill, New Delhi, 1974.

MA 321 DISCRETE MATHEMATICS 4 credits [3-1-0]

The language of sets: The concept of a set, Operations with sets, Computer operations with sets, The cardinality of a set, Recursively defined sets.

Functions and Matrices: The concept of a function, Special functions, Properties of functions, The pigeonhole principle, Composition of functions, Matrices.

Induction and algorithms: The division algorithm, Divisibility properties, Mathematical Induction, Algorithm correctness, The growth of functions,

Recursion: Recursively defined functions, Solving recurrence relations, Generating functions, Recursive algorithms.

Combinatorics and Discrete probability: The fundamental counting principles, Permutations, derangements, Combinations, Permutations and combinations with repetitions, The binomial theorem, The generalized inclusion and exclusion principle, Discrete probability.

Relations: Boolian matrices, Relations and digraphs, Computer representations of relations, Properties of relations, Operations on relations, The connectivity relations, Equivalence relations, Partial and total orderings.

Graphs: Computer representation of graphs, Paths, cycles and circuits, Eulerian and Hamiltonian graphs, Planner graphs, graph colouring, Trees: Spanning trees, Binary trees, Binary search trees.

Boolean algebras and combinatorial circuits: Boolean algebras, Boolean functions, Logic gates, Combinatorial circuits.

Essential Reading :

1. T. Koshy, *Discrete Mathematics with Applications*, Academic Press (An Imprint of Elsevier) First Indian Reprint 2005

MA 322 LINEAR PROGRAMMING 4 Credits [3-1-0]

Linear Programming : Lines and hyperplanes, convex sets, convex hull and their properties - Formulation of a Linear Programming Problem - Theorems dealing with vertices of feasible regions and optimality - Graphical solution - Simplex method (including Big M method and two phase method); infeasible and unbounded LPP's, alternate optima - Dual problem and duality theorems - Dual simplex method and its application in post optimality analysis - Revised simplex method - Sensitivity analysis - parametric programming .

Transportation problem: Introduction - existence of solution - degeneracy - MODI method (including the theory) - Assignment problem - Hungarian method for solving assignment problems - travelling salesman problem.

Integer Programming : Gomory's cutting plane method for an integer linear programming problem and a mixed integer linear programming problem.

Theory of Games: Introduction – Minimax (maximin) – Criterion and optimal strategy – Solution of games with saddle points – Rectangular games without saddle points – 2 X 2 games – dominance principle – m X 2 & 2 X n games –graphical method.

Dynamic programming : Multistage decision process - Concept of sub optimization - Principle of optimality - Computational procedure in dynamic programming -Application to problems involving discrete variables, continuous variables and constraints involving equations and inequalities - application to linear programming problem

Essential Reading :

1. H.A.Taha, *An Introduction to Operations Research* , PHI

Supplementary Reading:

1. Kambo, *Mathematical Progamming Techniques*, East-West Publi., Delhi
2. Kanti Swarup et. al., *Operations Research*, Sultan Chand and Co.,
3. S.D.Sharma , *Operations Research*, Kedarnath.
4. J.K.Sharma, *Operation Research*, MacMilan.
5. Hiller and Libermann, *Introduction to Operation Research*, TMH.
6. Wayne L.Winston, *Operation Research*, Thomson BrooCole.

MA 332 PROBABILITY 4 Credits [3-1-0]

Axiomatic definition of probability, Theorems on probability. Conditional probability and independence. Bayes's theorem, Geometric probability. Random variables, their properties. Some standard discrete and continuous variables. Mathematical expectation, variance, moments, moment generating function. Chebyshev's inequality. Functions of a r.v., their distributions and moments. Joint, marginal and conditional distributions, independence of random variables. Law of large numbers, Central limit theorem, Correlation and regression: Simple, multiple and partial. Sampling distributions. Estimation of parameters : Maximum likelihood and method of moments. Properties

of best estimates. Testing of hypotheses, Neyman-Pearson Lemma, standard tests for one and two sample problems.

Essential Reading:

1 V.K. Rohatgi and A.K. Md Ehsanes Saleh*, An Introduction to Probability and Statistics, John Wiley and sons*

Supplementary Reading:

1 S.C. Gupta and V.K. Kapoor, *Fundamentals of Mathematical Statistics* , Sultan Chand and Sons, New Delhi.
2 W.J. DeCoursey**,** *Statistics and Probability with Engineering Application, John Wiley and Sons Ltd.s*
3 T.T.Soong, *Fundamentals of Probability and Statistics for Engineers*, John Wiely and Sons Ltd
4 Douglas C. Montgomery, George C. Runger, *Applied Statistics and Probability for Engineers*, Third Edition

MA 342 DIFFERENTIAL GEOMETRY 4 Credits [3-1-0]

Vector Fields: height of the level set, level curves, Integral curve, smooth vector field, The tangent Space: tangent to the level set, gradient, **Surfaces:** Hyperplane, Lagrange multiplier, Vector Fields on Surfaces, maximal integral curve, orientation and its consistency, Osculating plane, Serret Frenet formula, Singular points and their classification Gauss, The Gauss map spherical image, one-sheeted hyperboloid, **Geodescis:** maximal geodesic, great circle, Parallel Transport, covariant derivative and acceleration, Fermi derivative, The Weingarten Map: shape operator, geodesic flow, **Curvature of plane curves:** center of curvature, radius of curvature, Isometries, Intrinsic differentiation, Gauss-Kronecker curvature, translation, rotation, Funda-mental theorem on curves, **Riemannin metrics:** Hyperbolic metric, Stereographic projection, Poincare metric, affine and Riemannian connection and covariance derivation, Applications of differential geometry in engineering and sciences.

Essential Reading:

1. J. A. Thorpe, *Elementary Topics in Differential Geometry* (Springer), 2004.

MA 372 STATISTICS LABORATORY 2 Credits [0-0-3]

1. Classification of raw data
2. Computation of arithmetic mean by different methods
3. Computation of geometric mean and harmonic mean for ungrouped and grouped data
4. Computation of quartiles, deciles and percentiles
5. Computation of mean deviation and quartile deviation
6. Computation root mean square deviation and standard deviation
7. Computation of raw moments and central moments
8. Computation of Karl Pearson's coefficient of correlation
9. Testing if the mean of a normal population is equal to a given value
10. Testing the equality of two population means
11. Testing if the variance of a normal population is equal to a given value
12. Testing the equality of two population variances

MA 373 LABORATORY WORKS ON LATEX AND MATLAB 2 Credits [0-0-3]

Introduction to Latex- Latex symbols- Type setting- Figures and Tables inserting – Formatting. **Introduction to Mathematica and Matlab**- Matrix computation using Matlab- Solving algebraic and differential equations using Mathematica and Matlab. Plotting graphs .

MA 401 REAL ANALYSIS 4 Credits [3-1-0]

Numerical sequences and series: Convergent sequences, Subsequences and Cauchy sequences, Special sequences, Upper and lower limits, Series of non-negative terms, Root and ratio tests, Summation by parts, Absolute convergence, Rearrangements, *Continuity*: Continuity and compactness and connectedness, Monotonic functions, *Differentiation*: The Mean value theorem, Continuity of derivatives, L'Hospital's rule, Taylor's Theorem, Differentiation of Vector-valued functions, *The Riemann-Stieltjes integral*: Definition, existence and properties, Integration and differentiation, Integration of vector-valued function, *Sequence and series of functions*: Uniform convergence and continuity, Differentiation and integration, Equi-continuous family of functions, The Stone-Weierstrass theorem, *Functions of several variables*: Linear transformations, Differentiation, The contraction principle, The inverse and implicit function theorems, The rank theorem, Derivatives of higher order, Differentiation of integrals

Essential Reading:

1. W. Rudin, Principles of Mathematical Analysis, McGraw Hill, 1986.

Supplementary Reading:

1. F. Morgan, Real Analysis, AMS Bookstore, 2005.

MA 402 MEASURE THEORY 4 Credits [3-1-0]

Outer measure, Measurable sets and Lebesgue measure, Nonmeasurable sets, Measurable functions, Littlewood's three principles, The Riemann integral, The Lebesgue integral of a bounded function over a set of finite measure, The integral of a nonnegative function, The general Lebesgue integral, Convergence in measure, Differentiation of monotone functions, Functions of bounded variation, Differentiation of an integral, Absolute continuity, Convex functions, The L^p spaces, The Minkowski and Holder inequalities, Convergence and completeness, Approximation in L^p, Bounded linear functionals on the L^p spaces.

Essential Reading:

1. E. D. Benedetto, *Real Analysis: Foundations and Applications*, Springer, 2002
2. H. L. Royden, *Real Analysis (Third Edition)*, Macmillan Publishing Company, 1988
3. G. De. Barra, *Measure Theory and Integration*, Horwood Publishing Corporation, 2003.

MA 403 LINEAR ALGEBRA 4 credits [3-1-0]

Vector spaces, Bases and dimensions, Change of bases and change of coordinates, Sums and direct sums, Spanning sums and independence, The dimension of a vector space, The complexification of a real vector space, Quotient spaces. Linear transformations, The kernel and image of a linear transformation, The rank and nullity theorem, Change of bases for linear transformations, Linear functionals, Representation of linear transformations by matrices, Dual spaces, Second dual, Reflexive spaces, Invariant subspaces, Direct-sum decomposition, Cyclic subspaces and Annihilators, The minimal polynomial, The rational and Jordan canonical forms, Inner product spaces, Orthonormal bases, Gram-Schmidt process. Adjoint operators, Normal, unitary, and self-adjoint operators, Spectral theorem for normal operators.

Essential Reading:

1. K. Hoffman and R. Kunze, *Linear Algebra*, PHI, 1971.
2. S. roman, *Advanced Linear Algebra*, Springer, 2007.

MA 404 FUNCTIONS OF A COMPLEX VARIABLE 4 credits [3-1-0]

Spherical representation of extended complex plane, Analytic functions, Branches of multiple-valued functions, Cauchy's theorem, Singularities, The Argument principle, Calculus of residues, Harmonic functions, Poisson's formula, The reflection principle, Conformal mappings, Geometry of Mobius

transformations, Open mapping theorem, The Maximum modulus theorem, Schwarz's lemma, Partial fractions and factorization, Stirling's formula, Jensen's formula, Hadamard's theorem.

Essential Reading:

1. L. V. Ahlfors, *Complex Analysis* (McGraw Hill International), 1979
2. J. B. Conway, *Functions of One Complex Variable* (Springer), 1978
3. W. Rudin, *Real and Complex Analysis* (McGraw-Hill), 1986

MA 405 PARTIAL DIFFERENTIAL EQUATIONS 4 credits [3-1-0]

Origin of first order partial differential equations, Cauchy's problem, Linear equations, Integral surfaces passing through a given curve, Surfaces orthogonal to a given system of surfaces, Nonlinear partial differential equations of the first-order, Cauchy's method of characteristics, Compatible systems of first-order equations, Charpit's method, Special types of first-order equations, Solutions satisfying given conditions, Jacobi's method, Origin of second order partial differential equations , Second and higher order equations in physics, Linear partial differential equations with constant coefficients, Equations with variable coefficients, Characteristic curves of second-order equations, Characteristics of equations in three variables, Solution of linear hyperbolic equations, Separations of variables, Integral transforms method, Nonlinear equations of second-order. Laplace's equation: The occurrence of Laplace's equation in physics, Elementary solutions of Laplace's equations, Family of equipotential surfaces, Boundary value problem, Problems with axial symmetry, Kelvin inversion theorems , theory of green's function for Laplace equation.

Essential Reading:

1. I.N. Sneddon: *Elements of Partial Differential Equations*, Dover, 2006

MA 407 TOPOLOGY 4 credits [3-1-0]

Topological spaces and continuous functions: Topological spaces, Basis for a topology, Order topology, Product topology, Subspace topology, Closed sets and limit points, Continuous functions, Homeomorphism, Metric topology, Quotient topology, Connectedness and compactness: Hausdorff spaces, Connected spaces, Connected subspaces of the real line, Compactness and local connectedness, Compact spaces, Compact subspaces of the real line, Limit point compactness, Local compactness, Countability and separation axioms: Countability axioms, Separation axioms, Normal spaces, Regular spaces, Completely regular spaces, Urysohn lemma, Urysohn metrization theorem, Tietze extension lemma, The Tychonoff theorem: Compactification, One-point compactification, The Stone-Cech compactification, Metrization theorems and paracompactness, Local finiteness, Complete metric spaces and function spaces: Compactness in metric spaces, Pointwise and compact convergence, Ascoli,s theorem, Baire's spaces and dimension theory, A nowhere differentiable function, Applications of topology in engineering and sciences.

Essential Reading:

1. J. R. Munkres: *Topology*: (Pearson Prentice Hall), 2005

MA 413 ANALYSIS-II 4 credits [3-1-0]

Functions on Euclidean spaces, continuity, differentiability; partial and directional derivatives, Chain Rule, Inverse Function Theorem, Implicit Function Theorem. Riemann Integral of real-valued functions on Euclidean spaces, measure zero sets, Fubini's Theorem. Partition of unity, change of variables. Integration on chains, tensors, differential forms, Poincare Lemma, singular chains, integration on chains, Stokes' Theorem for integrals of differential forms on chains. (general version). Fundamental theorem of calculus. Differentiable manifolds (as subspaces of Euclidean spaces), differentiable functions on manifolds, tangent spaces, vector fields, differential forms on manifolds, orientations, integration on manifolds, Stokes' Theorem on manifolds.

Essential Reading:

1. V. Guillemin and A. Pollack, *Differential Topology*, Prentice-Hall Inc., Englewood Cliffe, New Jersey, 1974.

Supplementary Reading:

1. W. Fleming, *Functions of Several Variables*, 2nd Ed., Springer-Verlag, 1977.
2. J.R. Munkres, *Analysis on Manifolds*, Addison-Wesley, 1991.
3. W. Rudin, *Principles of Mathematical Analysis*, 3rd ed., McGraw-Hill, 1984.
4. M. Spivak, *Calculus on Manifolds, A Modern Approach to Classical Theorems of Advanced Calculus*, W. A. Benjamin, Inc., 1965.

MA 423 DISCRETE MATHEMATICS 3 credits [3-0-0]

The language of sets: The concept of a set, Operations with sets, Computer operations with sets, The cardinality of a set, Recursively defined sets: *Functions and Matrices*: The concept of a function, Special functions, Properties of functions, The pigeonhole principle, Composition of functions, Matrices. *Induction and algorithms*: The division algorithm, Divisibility properties, Mathematical Induction, Algorithm correctness, The growth of functions, *Recursion*: Recursively defined functions, Solving recurrence relations, Generating functions, Recursive algorithms, *Combinatorics and Discrete probability*: The fundamental counting principles, Permutations, derangements, Combinations, Permutations and combinations with repetitions, The binomial theorem, The generalized inclusion and exclusion principle, Discrete probability. *Relations*: Boolian matrices, Relations and digraphs, Computer representations of relations, Properties of relations, Operations on relations, The connectivity relations, Equivalence relations, Partial and total orderings. *Graphs*: Computer representation of graphs, Paths, cycles and circuits, Eulerian and Hamiltonian graphs, Planner graphs, graph colouring, Trees: Spanning trees, Binary trees, Binary search trees. *Boolean algebras and combinatorial circuits*: Boolean algebras, Boolean functions, Logic gates, Combinatorial circuits.

Essential Reading:

1. T. Koshy, *Discrete Mathematics with Applications*, Academic Press (An Imprint of Elsevier) First Indian Reprint 2005

MA 424 OPERATIONS RESEARCH 3 credits [3-0-0]

Convex sets, Supporting and separating hyperplanes, Convex polyhedron and polytope, Convex functions, , Linear programming model, Graphical solution, The simplex method, Artificial variables, The Big-M method, Degeneracy and cycling, Dual of an LPP, The dual simplex method, *Transportation and assignment Problems*: Balanced transportation problem, Unbalanced transportation problem, Basic feasible solution by north-west corner rule, Row minima and column minima methods, Vogel's approximation method, Solution of TP, Assignment problem, Hungarian method of assignment, *Queuing Theory*: Introduction, Components of a queuing problem, Classification of queues, Steady, Transient and explosive states of a queue, Roles of Poisson process and exponential distribution in queuing theory, Queuing models, (M/M/1:∞/FIFO) Model, Distribution of waiting time and time spent by an unit in the system, (M/M/1:N/FIFO) model, (M/M/c:∞/FIFO) model, (M/M/c:N/FIFO) model, (M/E_k/1:∞/FIFO) model, (M/E_k/1:∞/FIFO) model, (M/E_k/1:1/FIFO) model, Real life examples of queuing models.

Essential Reading:

1. H.A. Taha, *Operations Research,* Prentice Hall, 1997

Supplementary Reading:

1. N. S. Kambo*, Mathematical Programming Techniques*, East West Press, 1997.

MA 426 ELEMENTORY STOCHASTIC PROCESS WITH APPLICATIONS 3 credits [3-0-0]

(Prerequisite: MA-201)

Definition and examples of stochastic processes, Classifications of stochastic processes, Markov chains, Definition and examples, Transition Probability matrices, Classification of states of a Markov chain, Determination of higher order transition probabilities, stability of a Markov chain, Graph theoretic approach, Markov chains with denumerable number of states, Reducible Markov Chains, Markov chains with continuous state spaces, General pure birth and death processes, Renewal processes, Renewal processes in continuous time, renewal equation, Renewal theorems, Residual and excess lifetime, Renewal reward processes, Regenerative renewal processes, Stochastic processes in queuing, General concepts of queuing systems, Steady state and transient behavior, Birth and death process in queuing theory, Network of Markovian queuing systems.

Essential Reading :

1. J. Medhi, *Stochastic Processes*, New Age Publishers, 2007.

MA 431 MATHEMATICAL METHODS 3 credits [3-0-0]

Bessel Equation: General solution of Bessel equation, Recurrence relations, Orthogonal sets of Bessel functions, Modified Bessel functions, Applications.

Legendre equation: General solution of Legendre equation, Legendre polynomials, Associated Legendre polynomials, Rodrigues formula, Orthogonality of Legendre polynomials, Application.

Green's function: Concept and calculation of Green's function, Approximate Green's function, Green's function method for differential equations.

Fourier Series, Generalized Fourier series, Fourier Cosine series, Fourier Sine series, Fourier integrals. Fourier transform, Laplace transform, Z-transform, Hankel transform, Mellin transform. Solution of differential equation by Laplace and Fourier transform methods.

Essential Reading:

1. G. N. Watson, *A Treatise on the Theory of Bessel Functions*, Cambridge University Press, 1944.
2. G. F. Roach, *Green's Functions*, Cambridge University Press, 1995.
3. A.D. Poularikas, *The Transforms and Applications Handbook*, CRC Press, 1996.
4. J. W. Brown and R. Churchill, *Fourier Series and Boundary Value Problems*, McGraw Hill, 1993.

MA 432 FINITE DIFFENCE METHODS 3 credits [3-0-0]

Iterative methods for linear systems: Classical iterative methods (Jacobi, Gauss-Seidel and successive overrelaxation (SOR) methods), Krylov subspace methods; GMRES, Conjugate-gradient, biconjugate-gradient (BiCG), BiCGStab methods, preconditioning techniques, parallel implementations.

Finite difference method: Explicit and implicit schemes, consistence, stability and convergence, Lax equivalence theorem, numerical solutions to elliptic, parabolic and hyperbolic partial differential equations.

Essential Reading:

1. D.S. Watkins, *Fundamentals of Matrix Computations, Second Edition*, Wiley-interscience, New York, 2002.
2. Joe D. Hoffman, *Numerical methods for Engineers and Scientist*, McGrow-Hill, 1993.
3. A. Quarteroni and A. Valli, *Numerical Approximation of Partial Differential Equations*, Springer, 1994.
4. K. Atkinson and W. Han, *Theoretical Numerical Analysis: A Functional Analysis Frame-work*, Springer-Verlag, New York, 2001.

MA 433 FINITE ELEMENT METHODS 3 credits [3-0-0]

Basic concept of the finite element method, Integral formulations and variational methods, The Lax-Milgram theorem, The abstract Galerkin method, Piecewise polynomial approximation in Sobolev spaces, Finite elements, Numerical quadrature, Applications to autonomous and non-autonomous problems, Optical error bounds in energy norms, Variational crimes, Apriori error estimates. The discontinuous Gaterkin methods, Adaptive finite element, The Autin-Nitscte duality argument, A posteriori error analysis.

Essential Reading:

1. C. Johnson, *Numerical Solution of Partial Differential Equations by the Finite Element Method*, Cambridge Universityh Press, 1987.
2. J. N. Reddy, *An Introduction to Finite Element Method*, McGraw Hill, 1993

Supplementary Reading :

1. P. G. Ciarlet, *The Finite Element Method for Elliptic Problems*, North-Holland, Amsterdam, 1978.
2. K. Erikssen et al., *Computational Differential Equations*, Cambridge University Press, 1996.
3. C. A. J. Fletcher, *Computational Galerkin Methods*, Springer-Verlag, New-York inc, 1984.

MA 438 DYNAMICAL SYSTEMS 4 credits [3-1-0]

Review of stability for linear systems. Flow defined by nonlinear systems of ODEs, linearization and stable manifold theorem. Hartman-Grobman theorem. Stability and Lyapunov functions. Planar flows: saddle point, nodes, foci, centers and non-hyperbolic critical points. Gradient and Hamiltonian systems. Limit sets and attractors. Poincare map, Poincare Benedixson theory and Poincare index.

Essential Reading:

1. L. Perko, *Differential Equations and Dynamical Systems*, Springer Verlag, NY, 1991.

Supplementary Reading:

1. V.I. Arnold, *Ordinary Differential Equations*, Prentice Hall of India, New Delhi, 1998.
2. M.W. Hirsch and S. Smale, *Differential Equations, Dynamical Systems and linear Algebra*, Academic Press, NY, 1974.

MA 470 LABORATORY WORKS ON REAL LIFE PROBLEMS – I 2 credits [0-0-3]

MA 471 OBJECT ORIENTED PROGRAMMING PRACTICE LABORATORY 2 credits [0-0-3]

Computational works are to be done on the following 12 topics.

1. Finding all topologies from a 4-point set
2. Income tax calculation
3. Calculation of quintiles
4. Drawing all random samples from a given population and finding the unbiased estimate of the population mean and the variance
5. Calculation of central moments
6. Computations of roots of algebraic and transcendental equations by four methods

7. Interpolation by four methods
8. Numerical integration and numerical solution of differential equations
9. Listing all primes and twin primes up to certain number
10. Listing all divisors of certain numbers
11. Finding the determinant and inverse of a matrix
12. Finding eigen values and eigen vectors of a given matrix

MA 501 ABSTRACT ALGEBRA 4 Credits [3-1-0]

Groups, Subgroups, Centralizers, Normalizers, Stabilizers, Kernels, Cyclic groups, Subgroups generated by a subset of a group, Quotient groups, Lagrange's theorem, Homomorphisms, Isomorphism theorems, Composition series, Solvable groups, Nilpotent groups, Symmetric group, Alternating group, Group actions, Permutation representations, Automorphisms, p-groups, The Sylow theorems, Simplicity of the Alternating group, Direct products of groups, Fundamental theorem of finitely generated abelian groups, Groups of small orders, Rings, Ring homomorphisms, Ideals, Ring of fractions, The Chinese remainder theorem, Euclidean domains, Principal domains, Unique factorization domains, Matrix rings, Polynomial rings, Irreducible Criteria, Eisenstein's criterion.

Essential Reading:

1. D. S. Dummit & R. M. Footee, *Abstract Algebra*, Wiley, 2008

Supplementary Reading:

1. I. N. Herstien, *Topics in Algebra*, Wiley, 2008
2. J. J. Rotman, *An Introduction to the Theory of Groups*, Springer, 1999

MA 502 FUNCTIONAL ANALYSIS 4 Credits [3-1-0]

Normed spaces, Banach spaces, Further properties of normed spaces, Finite dimensional normed spaces and subspaces, Compactness and finite dimension, Bounded and continuous linear operators, Linear functionals, Linear operators and functionals on finite dimensional spaces, Normed spaces of operators, Dual spaces, Inner product spaces, Hilbert spaces, Further properties of inner product spaces, Representation of functionals on Hilbert spaces, Hilbert-adjoint operator, Self-adjoint, unitary and normed operators, Fundamental theorems for normed and Banach spaces: Zorn's lemma, Hahn-Banach theorem, Hahn-Banach theorem for complex vector spaces and normed spaces, Adjoint operators, Reflexive spaces, Topological vector spaces.

Essential Reading:

1. Y. Eidelman, V.D. Milman, A. Tsolomitis, Functional *Analysis: An Introduction*, AMS Bookstore, 2004
2. E. Kreyszig, *Introductory Functional Analysis with Applications*, Willey, 1978

MA 503 THEORY OF RINGS AND FIELDS 4 Credits [3-1-0]

Simple groups and solvable groups, nilpotent groups, simplicity of alternating groups, composition series, Jordan-Holder Theorem. Semidirect products. Free groups, free abelian groups.

Rings, Examples (including polynomial rings, formal power series rings, matrix rings and group rings), ideals, prime and maximal ideals, rings of fractions, Chinese Remainder Theorem for pairwise comaximal ideals.

Euclidean Domains, Principal Ideal Domains and Unique Factorizations Domains. Poly-nomial rings over UFD's.

Fields, Characteristic and prime subfields, Field extensions, Finite, algebraic and finitely generated field extensions, Classical ruler and compass constructions, Splitting fields and normal extensions, algebraic closures. Finite fields, Cyclotomic fields, Separable and inseparable extensions.

Galois groups, Fundamental Theorem of Galois Theory, Composite extensions, Examples (including cyclotomic extensions and extensions of finite fields). Norm, trace and discriminant. Solvability by radicals, Galois' Theorem on solvability. Cyclic extensions, Abelian extensions, Trans-cendental extensions.

Essential Reading:

1. M. Artin, *Algebra*, Prentice Hall of India, 1994.
2. D.S. Dummit and R. M. Foote, *Abstract Algebra*, 2nd Ed., John Wiley, 2002.
3. J.A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa, 1999.
4. N. Jacobson, *Basic Algebra I, 2nd Ed*., Hindustan Publishing Co., 1984, W.H. Freeman, 1985.

MA 504 INTRODUCTION TO SEVERAL COMPLEX VARIABLES 4 credits [3-1-0]

Review of the theory of functions of one complex variables; Holomorphy, power series in several complex variables, Hartogs property; Domains of holomorphy, plurisubharmonic functions, pseudoconvex domains; Entire functions, weighted L2 spaces, Bergman projectors for L2 spaces with quadratic plurisubharmonic weights; Applications: Berezin-Toeplitz quantization, Catlin-D'Angelo-Quillen Theorem, analytic proof of the Nullstallensatz; Solving the ∂ equation in L2 spaces with global plurisubharmonic weights; Fefferman/Boutet de Monvel-Sjöstrand asymptotics for Bergman projectors for "nonlinear" weights; Quick introduction to complex manifolds, complex line bundles and powers of line bundles; Applications of Bergman kernel asymptotics: Kodaira's embedding theorem and the Catlin-Tian-Yau-Zelditch asymptotics.

Essential Reading:

(1) Hormander, L., Introduction to Complex Analysis in Several Variables, 3rd ed., North-Holland, 1990
(2) Krantz, S. G., Function Theory of Several Complex Variables, AMS Chelsea Publishing, 2001.
(3) Rudin, W., Function Theory in the Unit Ball of Cn, Springer-Verlag, 1980

MA 510 CALCULUS OF SEVERAL VARIABLES 4 credits [3-1-0]

Euclidean Space: Vector space, Definition of euclidean space, Orthinormal basis, The dual and second dual, Norms in the dual, The space L(E, F), Open sets, Closed sets, Completeness, Borel covering theorem, Equivalence of norms, Connected open sets.
Mappings and their duals: Continuous mappings, Definition of differentials, Differentiability implies continuity, Special cases, Function of class C^1, Mappings of class C^1, Composition of differentiable mappings, Higher differentials.
Mappings into reals: Taylor's theorem for one variable, Taylor's theorem for n variables, Absolute maxima and minima, Volume of a set, Integral on a closed interval, Condition for integrability, Integral on an open set, Iterated integral, Volume of n-ball, Interchange of order of integration with differentiation.
Main theorems on mappings: Regular elements in L(E, F), Inverse of a mapping, Implicit function theorem, Determinant, Oriented volume, Change of variables in integration.
Essential Reading:

1. S. Salas and G.J. Etgen, *Calculus: Several Variables*, John Wiley, 2003

T. P. Dick, C. M. Patton, *Calculus of Several Variables*, PWS Pub. Co., 1995

MA 511 DIFFERENTIAL GEOMETRY 4 credits [3-1-0]

Vector Fields: height of the level set, level curves, Integral curve, smooth vector field, The tangent Space: tangent to the level set, gradient, Surfaces: Hyperplane, Lagrange multiplier, Vector Fields on Surfaces, maximal integral curve, orientation and its consistency, Osculating plane, Serret Frenet formula, Singular points and their classification Gauss, The Gauss map spherical image, one-sheeted hyperboloid, Geodescis: maximal geodesic, great circle, Parallel Transport, covariant derivative and

acceleration, Fermi derivative, The Weingarten Map: shape operator, geodesic flow, Curvature of plane curves: center of curvature, radius of curvature, Isometries, Intrinsic differentiation, Gauss-Kronecker curvature, translation, rotation, Funda-mental theorem on curves, Riemannin metrics: Hyperbolic metric, Stereographic projection, Poincare metric, affine and Riemannian connection and covariance derivation, Applications of differential geometry in engineering and sciences.

Essential Reading:

1. J. A. Thorpe, *Elementary Topics in Differential Geometry* (Springer), 2004.

MA 512 FOURIER ANALYSIS 4 credits [3-1-0]

Fourier series and integral: Fourier coefficient and series, Criteria for point-wise convergence, Fourier series of continuous functions, Convergence in norm, Summability methods, The Fourier transforms of L^1 functions, The Fourier transform on L^p, $p > 2$, The convergence and summability of Fourier integrals. *The Hardy-Littlewood maximal functions*: Approximation of the identity, Weak-type inequalities and almost everywhere convergence, The Marcinkiewicz interpolation theorem, The Hardy-Littlewood maximal function, The dyadic maximal function. *The Hilbert transform*: The conjugate Poisson kernel, The theorems of M. Riesz and Kalmogrov, Truncated integrals and point-wise convergence, Multipliers

Essential Reading:

1. J. Duoandikoetxea, *Fourier Analysis*: AMS Bookstore, 2001.

MA 513 DIFFERENTIAL TOPOLOGY 4 credits [3-1-0]

Manifolds and Smooth Maps: Derivatives and tangents, The inverse function theorem and immersions, submersions, transversability, homotopy and stability, Sard's theorem and Morse functions, embedding manifolds into Euclidean spaces, Simplicial surfaces: Simplices, Simplicial complexes, Simplicial surfaces, The Euler characteristic, Proof of the classification of compact and connected surfaces, Smooth surfaces, Tangent and normal vectors, First fundamental forms, Directional derivatives. Coordinates free, Dirtectional derivatives-coordinates, Length and area, Isometries, Transversality and interactions: Manifolds with boundaries, one-manifolds and some consequences, Transversality and interaction theorem mod 2, winding numbers and the Jordan-Brouwer separation theorem, Oriented interaction theorem: Motivation, orientation, oriented interaction number, Lefschetz fixed-point theory, Vector fields and the Poincare-Hopf theorem, The Hopf degree theorem, The Euler characteristic and triangulations, Intergration on manifolds: Introduction, exterior algebra, differential forms, interior of manifolds, exterior derivatives, cohomology with forms, Stokes' theorem, Integration and mappings, the Gauss-Bonnet theorem.

Essential Reading:

1. D. B. Gauld, *Differential Topology: An Introduction*, Dover Publication 2006.

MA 514 RINGS AND MODULES 4 credits [3-1-0]

Ring of continuous functions, matrix rings, polynomial rings, power series rings, Laurent rings, Boolean rings, Direct products, local rings, prime fields, Euclidean domains, PID, Unique factorization domains, Eisenstein's criteria, modules, direct sum, free modules, quotient modules, simple modules, homomorphisms, module's over PID's, Artinian modules, Noetherian modules, Artian rings, Noetherian rings, Nil Radicals, Jacobson radicals.

Essential Reading:

1. C. Musili, *Introduction to Rings and Modules*, Narosa,

MA 515 HOMOTOPY THEORY 4 credits [3-1-0]

Brouwer Fixed point theorem, categories, Functors, Natural transformations, Natural equivalence, Homtopy, Convexity, Contrctibility, Mapping cylinder and cones, Paths and path connected spaces, Affine spaces, Affine maps, Homotopy as equivalence relation, Contractible Spaces, Homotopy of maps, Homotopy classes, Homotopically equivalent spaces with examples, Fundamental Groups, Induced maps and homomorphisms, Lifting property, Calculation of first homotopy groups, Function spaces, Group objects and cogroup objects, Loop space and suspension, Exact sequence of homotopy groups, Homotopy lifting property, Homotopy extension property, Fibrations and cofibrations, CW-complexes and their examples, attaching of maps, Homotopy groups of CW-complexes, The effect on the homotopy groups of a cellular extension, Spaces with prescribed homotopy groups, Weak homotopy equivalences and CW-approximation Homotopy extension and classification theorems, Study of some cases where homotopy theory is applied in electrical engineering.

Essential Reading:

1. J. Rotman, *Algebraic Topology*, Springer-Verlag, 2004

MA 516 OPERATOR THEORY 4 credits [3-1-0]

Banach Spaces: The Banach space of continuous functions, Abstract Banach spaces, The conjugate space of continuous linear functionals, Examples of Banach spaces: c_0, l^1 and l^∞, Weak topologies on Banach spaces, The Alaoglu theorem, The Hahn-Banach theorem, The conjugate space of C([0,1]). The open mapping theorem, The Lebesgue spaces: L^1 an L^∞, The Hardy spaces: H^1 and H^∞, Banach algebras: The Banach algebra of continuous functions, Abstract of Banach algebras, Abstract index in a Banach algebra, The space of multiplicative linear functions, The Gelfand transform, The Gelfand-Mazur theorem, The Gelfand theorem for commutative Banach algebras, The spectral radius formula, The Stone-Weirstrass theorem, The generalized Stone-Weirstrass theorem, The disk algebra, The algebra of functions with absolutely convergent Fourier series, The algebra of bounded measurable functions, Geometry of Hilbert space: Inner product spaces, The Cauchy-Schwarz inequality, The Pythagorian theorem, Hilbert spaces, Examples of Hilbert Spaces: C^n, l^2, L^2, and H^2. The Riesz-Representation Theorem, The existence of orthogonal bases, The dimension of Hilbert spaces, Operators on Hilbert space and C^*-algebras: The adjoint operators, Normal and self-adjoint operators, Projections and subspaces, Multiplication operators and maximal abelian algebras, The bilateral shift operators, C^*-algebras.

Essential Reading:

1. R. G. Douglas: *Banach Algebra Techniques in Operator Theory*, Springer, 1998

MA 517 LIE ALGEBRA 4 credits [3-1-0]

Definitions and examples, Solvable and nilpotent Lie algebras, Simple and semi-simple Lie algebras, Levi's theorem, Idealizer and centralizer, Derivation of a Lie algebra, Structure constant, Special linear algebra, Lie groups and Lie algebras, Classical groups and their Lie algebras, Cartan-Killing form, Root-space decomposition of a Semi-simple Lie algebra, Properties of root space, Simple root system and classification of finite dimensional complex Semi-simple Lie algebra, Cartan matrix, root diagrams, Dynkin diagrams, Weyl group of a root system, Weyl reflection, Real forms of Lie algebras and their classification through Satake and Vogan diagram, Applications of Lie groups and Lie algebras to robotics, Genetic coding, Control theory, Computer vision, Particle physics.

Essential Reading:

1. K. Erdmann, M. J. Wildon, *Introduction to Lie Algebras*, Springer 2006

MA 518 ADVANCED COMPLEX ANALYSIS 4 credits [3-1-0]

Compactness and Convergence in the space of analytic functions, Riemann mapping theorem, Reflection principle, Weierstrass factorization theorem, The Reimann zeta function, Runge's theorem, Simple connectedness, Picard's little theorem and Picard's big theorem, Normal families, Equicontinuity, Arzela's theorem, Normality and continuity, Conformal mapping of polygons, The

Schwarz-Christiffel formula, Harnock's of harmonic functions, Diridhlet's principle, The Weierstrass P-function, Analytic continuation, The Monodromy theorem, Picard's theorem, Lacunary values.

Essential Reading:

1. L. V. Ahlfors, *Complex Analysis* (Mc-Graw Hill International)

Supplementary Reading:

1. J. B. Conway, *Functions of One Complex Variable* (Narosa).
2. M. Rao & H. Stetkaer, *Complex Analysis: An Invitation* (World Scientific)

MA 519 MULTI LINEAR ALGEBRA 4 credits [3-1-0]

Tensor product: Multilinear mappings of vector spaces, Existence and universal property of the tensor product, Commutativity and associativity of the tensor product, The tensor product in terms of coordinates, Tensor products and spaces of linear mappings, Tensor algebras: Covariant, contravariant and mixed tensors, Classical definition and notation of a tensor in terms of coordinates, Structure tensor of an algebra, Mixed tensor algebra, Universal property of the tensor algebra, symmetry and alteration, Exterior algebra: Exterior powers and p-vectors, Alternation operator, Exterior powers of linear mappings, Exterior algebra, Duality and p-forms, Exterior algebra, duality in exterior algebra, applications to vector space bundles, exterior differentiation, Tensor products and standard algebras: Graded vector spaces, graded algebra, the graded tensor algebras, commutative algebra, the exterior algebra of a finite dimensional vector spaces, Grassman algebras: Alternate k-linear functions, exterior multiplications, homogeneous elements, decomposable elements, Recent developments.

Essential Reading:

1. R. Merris, *Multilinear Algebra*, (CRC Press) 1997

MA 520 AUTOMATA THEORY 4 credits [3-1-0]

Finite Automata, Regular expressions, equivalence of finite automata and expressions, Moore and Mealy Machines, Properties of regular sets: Pumping lemma, closure properties and decision algorithms, Minimizing finite automata, Context-free grammars, Pushdown automata

Essential Reading:

1. J. E. Hopcroft & J. D. Ullman, *Introduction to Automata theory, Languages and computations* (Narosa)

MA 521 COMBINATORICS 4 credits [3-1-0]

Graphs, Trees, Colorings of graphs and Ramsey's theorem, The addressing problem for graphs, The principle of inclusion and exclusion, inversion formulae, Permanents, Elementary counting, Stirling numbers, Recursions and generating functions, Partitions, (0,1)-matrices, Latin squares, Hadamard matrices, 1 Designs, Codes and designs, Strongly regular graphs and partial geometries, Orthogonal Latin squares, Projective and combinatorial geometries, Gaussian numbers and q-analogues, Lattices and Möbius inversion, Combinatorial designs and projective geometries.

Essential Reading:

1. V. K. Balakrishnan, *Theory and Problems of Combinatorics*, McGraw Hill, 1994
2. J. H. Van Lint and R.M. Wilson, *A Course in Combinatorics*, Cambridge University Press, 2001.

MA 522 OPERATIONS RESEARCH 4 credits [3-1-0]

Nonlinear programming problem: Kuhn-Tucker optimality conditions and convex programming: Kuhn-Tucker first order optimality conditions, Second order optimality conditions, Lagrange's method, Convex programming problem, Sufficiency of Kuhn-Tucker conditions, Lagrangian saddle-

point and duality, Duality of convex programs - Quadratic programming (Wolfe's and Beale's methods). **Network analysis:** Preliminaries - min cost flow problem - max flow problem - CPM/PERT. Scheduling and sequencing. **Queuing theory:** Queuing theory: Introduction, Components of a queuing problem, Classification of queues, Steady, transient and explosive states of a queue, Roles of Poisson process and exponential distribution in queuing theory, Queuing models, (M/M/1:∞/FIFO) model, Distribution of waiting time and time spent by an unit in the system, (M/M/1:N/FIFO) model, (M/M/c:∞/FIFO) model, (M/M/c:N/FIFO) model, ($M/E_k/1:\infty$/FIFO) model, ($M/E_k/1:\infty$/FIFO) model, ($M/E_k/1:1$/FIFO) model, Examples of queuing models. **Inventory Control:** Introduction, Inventory control for single commodity - deterministic inventory models (without and with shortages) - Probabilistic inventory (both discrete and continuous) control models.

Essential Reading:

1. H.A.Taha, *An Introduction to Operations Research* , PHI, 2002

Supplementary Reading:

1. H.M.Wagner : *Principles of Operations Research*, Prentice Hall of India, Delhi. , 1996
2. J.C. Pant, *Introduction to Optimisation*, Jain Brothers, Delhi, 2000.
3. F. S. Hillier & G. J. Lieberman, *Introduction to Operations Research*, Tata McGraw-Hill, 2005.
4. N.S. Kambo: *Mathematical Programming Techniques* Affiliated East-West Press Ltd, 1984.

MA 523 DISCRETE MATHEMATICS 4 credits [3-1-0]

Functions and matrices: Special functions, Properties of functions, pigeonhole principle, Composition of functions.

Induction and algorithms: The division algorithm, Divisibility properties, Mathematical induction, Algorithm correctness, The growth of functions, Complexities of algorithms.

Recursion: Recursively defined functions, Solving recurrence relations, Generating functions, Recursive algorithms, Correctness of recursive algorithms, Complexities of recursive algorithms.

Combinatorics and discrete probability: The fundamental counting principles, The generalized inclusion and exclusion principle, Discrete probability.

Relations: Boolian matrices, Relations and digraphs, Computer representations of relations, Properties of relations, Operation on relations, The connectivity relations, Equivalence relations, Partial and total orderings.

Graphs: Computer representation of graphs, Isomorphic graphs, Paths, cycles and circuits, Eulerian and Hamiltonian graphs, Planner graphs, graph colouring.

Trees: Spanning trees, Minimal spanning trees, Rooted trees, Binary trees, Binary search trees.

Boolean algebras and combinatorial circuits: Boolean algebras, Boolean functions, Logic gates, Combinatorial circuits, Minimization of combinatorial circuits, Recent developments.

Essential Reading:

1. T. Koshy, *Discrete Mathematics with Applications*, Academic Press (An Imprint of Elsevier) First Indian Reprint 2005.

Supplementary Reading:

1. R. Johnsonbaugh, *Discrete Mathematics*, Pearson Prentice Hall, 2008

MA 524 STATISTICAL METHODS 4 credits [3-1-0]

Random variables: Distribution functions, Properties of distribution functions, Discrete random variables and probability mass functions, Continuous random variables and probability density functions, Two dimensional random variables: Joint, marginal and conditional distributions, Independence, Mathematical expectations: Mathematical expectation of function of a random variable, Linearity of mathematical expectation, Expectation in joint distributions, Conditional expectation and conditional variance, Moments, cumulants and their generating functions, Conditional expectations and conditional variance, Theoretical discrete distributions: Binomial, Poisson, hyper-geometric, Negative binomial and multinomial distributions, Recurrence relations for probabilities and moments, Theoretical continuous distributions: Exponential, gamma, beta and

normal distributions, Applications of normal distribution, Chi-square distribution: Test for goodness of fit and population variance, t-distribution: Test for single mean and difference of two means, F-distribution: Test for equality of two population variances, Law of large numbers: Chebyshev's inequality, Weak law of large numbers, De-Moivre Laplace theorem, Central limit theorems.

Essential Reading:

1. J. E. Freund, *Mathematical Statistics with Applications*, Miller 2003.

Supplementary Reading:

1. J. Medhi, *Statistical Methods, An Introductory Text*, New Age, 1992
2. K. Knight, *Mathematical Statistics*, CRC Press, 1999

MA 525 ERGODIC THEORY 4 credits [3-1-0]

Measure preserving transformation, Isomorphism and spectral invariants, Measure preserving transformation with pure point spectrum, Entropy.

Essential Reading:

1. P. Walters, *Ergodic Theory*, Springer Verlag, 1981

MA 527 FRACTALS 4 credits [3-1-0]

Fractal examples: the Traidic Cantor dust, the Sierpinski Gasket, A space of strings, Turfle graphics, Sets defined recursively, number system, Metric topology, Uniform convergence, The Hausdorff metric, Metrics for strings, Topological dimension, Small and large inductive dimension, Two dimensional euclidean space, Other topological dimensions.

Essential Reading:

1. G. A. Edger, *Measure, Topology and fractal Geometry*, Springer Verlag.
2. M. Barnsley, *Fractals Everywhere*, Morgan Kaufmann, 2000.
3. H. O. Peitgen, *Chaos and Fractals*, New Frontiers of Science, Springer, 2004

MA 529 INFORMATION THEORY 4 credits [3-1-0]

Information Theory and Source Coding: Introduction to information theory, Uncertainty and information, Average mutual information and entropy, Information measures for continuous random variables, Source coding theorem, Huffman coding, The Lempel-Ziv algorithm, Tun length encoding and PCX format, Rate distortion function, Optimum quantizer design, Introduction to image compression, The Jpeg standard for lossless compression, The Jpeg standard for Lossy compression, Channel Capacity and Coding: Channel models, Channel capacity, Channel coding, Information capacity theorem, The Shannon limit, Random selection of codes, Cryptography: Introduction to cryptography, An overview of encryption techniques, Operations used by encryptions algorithm, Symmetric (secret key) cryptography, Data encryption standards (DES), International data encryption algorithm (IDEA), RC ciphers, Assymmetric (public key) algorithms, Way hashing, Other techniques, Secure communication using chaos functions, Cryptanalysis, Politics of cryptography, Recent developments.

Essential Reading:

1. H. S. M. Coxeter, *Elements of Information Theory*, John Wiley, 2005.

Supplementary Reading:

1. R. Bose, *Information Theory Coding and Cryptography*, Tata McGraw-Hill, 2003
2. S. Goldman, *Information Theory*, Dover, 2005

MA 531 BOUNDARY LAYER THEORY 4 credits [3-1-0]

Outline of viscous flows: Real and perfect fluids, viscosity, Reynolds number, Laminar and turbulent flows, Asymptotic behavior at large Reylonds numbers, Fundamentals of boundary-layer theory: Boundary-layer concept, Laminar boundary-layer on a flat plate at zero incidence, Separation of the boundary-layer. Field equations for flows of Newtonian fluids: Continuity equation, Momentum equation, General stress state of deformation bodies, General state of deformation of flowing fluids, Relation between stresses and rate of deformation, Stokes hypothesis, Navier-Stokes equations, Energy equations, Equations of motion in different coordinate systems. Exact solutions of the Navier-Stokes equations: Couette-Poiseuille flows, Plane stagnation point flow, Flow at a wall suddenly set into motion, Stokes first problem, Flow at an oscillation flow, Stokes second problem, Unsteady plane stagnation-point flow. Boundary-layer equations in plane flow: Setting the boundary-layer equations, Wall friction, separation and displacement, Dimensional representation of the boundary layer equations, Plate boundary- layer. Thermal boundary- layer: Boundary layer equations for the temperature field, Effect of the Prandtl number.

Essential Reading:

1. H. Schlichting and K. Gersten, *Boundary-Layer Theory*, Springer, 2003.

MA 532 NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS 4 credits [3-1-0]

Parabolic equations in one space dimension, Explicit and implicit formula, Convergence and stability, Derivative boundary conditions, Parabolic equations in three dimensions, Explicit methods and their stability, Alternating direction implicit methods, nonlinear equations, Elliptic equations in two dimensions, Laplace equation in a square, the Nuemann problem, Mixed boundary conditions, Non-rectangular regions, Alternative method for constructing difference formula, Properties of difference formula, The solution of elliptic difference equations, Direct factorization methods, Successive over relaxation, A.D.I methods, Conjugate gradient and related methods, First order hyperbolic equations, Explicit and implicit schemes and their stability.

Essential Reading:

1. A.R. Mitchel & D.F. Grifflts: *The Finite Difference Methods in Partial Differential Equations*, Willey, 1980

MA 533 MODERN THEORY OF PARTIAL DIFFERENTIAL EQUATIONS 4 credits [3-1-0]

Theory of distributions: support, test functions, regular and singular distributions, generalized derivatives,

Sobolev spaces: Definition and basic properties, approximation by smooth functions, dual spaces, trace and imbedding results

Eliptic boundary value problems: abstract variational problems, Lax-Milgram lemma, weak solutions and wellposedness with examples, regularity result, maximum principles, eigen value problems.

Semigroup theory and applications: exponential map, C-semigroups, Hille-Yosida and Lummer-Phillips theorems, applications to heat and wave equations

Essential Reading:

1. S Kesavan, Topics in Functional Analysis, Wiley Eastren Ltd, New Delhi, 1989.

Supplementary Reading:

1. L C Evans, Partial Differential Equations, AMS, Providence, 1998.

2. M Renardy and RC Rogers, An introduction to Partial Differential Equations, 2nd edition, Springer, New York, 2004.

MA 534 GEOMETRY OF ROBOTICS 4 credits [3-1-0]

Robotics: An introduction, Theoretical robotics, Mathematical ingredients: Lie groups, subgroups, the Proper Euclidean group, Chasle's theorem, SE(3), Reuleaux's lower pairs, Lie algebras, Commutators, Exponential mapping, Robots Jacobian and Derivatives, Robot Kinematics: Inverse kinematics for 3-R wrists, 3-R Robots and planar motion, Planar 4-bar, Line geometry, Plucker coordinates, Inverse robots Jacobian, Representation SO(3), Screw systems, Clifford algebra, Dual quarternions, Euclidean geometry, Pieper's theorem, the T3 Robot, the PUMA, Statics: Gripping, Friction, Dynamics: Lagrangian and Hamiltonian Dynamics of Robots. Robot equation of motion, Constrained dynamics, trees and stars, Serial robot with end effector constraints, Biped walking, Differential geometry, Controlling of Robots, Hybrid control, Non linear control and Lie brackets.

Essential Reading:

2. J.M. Seling, *Geometric Fundamentals of Robotics*, Springer (2005)

Supplementary Reading:

1. R M Murray, S. Sastry, Li Z, *A mathematical introduction to robotic manipulation*, CRC press, Boca Raton, Florida

MA 535 CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS 4 credits [3-1-0]

Calculus of Variations: Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema. Variational methods for boundary value problems in ordinary and partial differential equations.

Integral equations : Classification of Liner Integral Equations: Fredholm, Volterra, Integro-Differential Equations, Singular Integral Equations, Converting Volterra Equation to ODE, Conversion of IVP to Volterra equation Conversion of BVP to Fredholm Equation ; Fredholm Integral Equations - Decomposition method, Direct Computation method, successive approximation method, method of successive substitutions, Homogeneous Fredholm Equations, Comparison between Alternative methods ; Volterra Integral Equation – Adomian Decomposition methods, Series Solution method, converting Volterra Equation to VIP, Successive Approximation method, successive substitution method, comparison between alternative methods ; Intergro-Differential Equations – Introduction, Direct Computation method, Adomian Decomposition Method. Conversion to Fredholm integral Equation. Volterra Intego-Differential equation Series Solution, Decomposition Method, Conversion to IVP.

Essential Reading:

1. A. S. Gupta, *Calculus of Variations*, Prentice-Hall Of India Pvt. Ltd., 2004
2. M. L. Krasnov, A. I. Kiselev, and G. I. Makarenko, *Problems and Exercises in Integral Equations*, Mir Publ., Moscow, 1971.

Supplementary Reading:

1. J. N. Reddy, *An introduction to the Finite Element Method*, McGraw Hill, NY, 2006.
2. Shanti Swarup, *Linear Integral Equations*, Krishna Prakashan Media (Pvt.) Ltd., 2003.
3. J. Kondo, *Integral Equations*, Clarendon Press, Oxford, 1997.
4. C. Corduneanu, *Integral Equations and Applications*, Cambridge Univ.Press, Cambridge–New York, 1991.
5. A. C. Pipkin, *A Course on Integral Equations*, Springer-Verlag, New York, 1991.
6. A.W. Wazwaz, *A First Course in Integral Equation*, World Scientific, 1997.
7. A.J. Jerri, *Introduction to Integral Equation with Application*, Wiley Interscience, 1999.

MA 536 NUMERICAL METHODS FOR DIFFERENTIAL EQUATIONS 4 credits [3-1-0]

Introduction. Runge-Kutta methods -derivation, error bounds and error estimates. Weak stability theory for Runge-Kutta methods. Order and convergence of the general explicit one-step methods. Linear multi-step methods -derivation, order consistency, zero-stability and convergence. Weak stability theory for general linear multi-step methods. Predictor-Corrector methods. Stiff systems.

Essential Reading:

1. J. C Butcher, *Numerical Methods for Ordinary Differential Equation*, Wiley publisher, 2008.

MA 537 NUMERICS OF SINGULARLY PERTURBED DIFFERENTIAL EQUATIONS 4 credits [3-1-0]

First-order Initial-Value Problems: Continuous problem, classical difference schemes, necessary conditions, uniformly convergent exponentially fitted schemes, artificial viscosity, constant fitting factors, optimal error estimates, Fitted mesh methods in one dimension, Convergence of fitted mesh methods for Reaction-diffusion problem and convection-diffusion problems.

Essential Reading:

R.E. O'Malley, Singular Perturbation Methods for Ordinary Differential Equations, Springer-Verlag, New York, 1991.

1. J.J.H Miller, E.O. Riordan, G.I Shishkin, *Fitted Numerical Methods for Singular Perturbation Problems*, World Scientific, Singapore, 1996.

Supplementary Reading:

1. P.A. Farrell, A.F. Hegarty, J.J.H Miller, E.O. Riordan, G.I Shishkin, *Robust Computational Techniques for Boundary Layers*, Chapman & Hall/CRC Press, Boca Raton, FL, 2000.
2. E.P. Doolan, J.J.H. Miller, and W.H.A. Schildres. *Uniform Numerical Methods for Problems with Initial and Boundary Layers*. Boole Press, Dublin, 1980.

MA 538 FLUID DYNAMICS 4 credits [3-1-0]

Review of gradient, divergence and curl. Elementary idea of tensors. Velocity of fluid, Streamlines and path lines, Steady and unsteady flows, Velocity potential, Vorticity vector, Conservation of mass, Equation of continuity. Equations of motion of a fluid, Pressure at a point in fluid at rest, Pressure at a point in a moving fluid, Euler's equation of motion, Bernoulli's equation. Singularities of flow, Source, Sink, Doublets, Rectilinear vortices. Complex variable method for two-dimensional problems, Complex potentials for various singularities, Circle theorem, Blasius theorem, Theory of images and its applications to various singularities. Three dimensional flow, Irrotational motion, Weiss's theorem and its applications. Viscous flow, Vorticity dynamics, Vorticity equation, Reynolds number, Stress and strain analysis, Navier-Stokes equation, Boundary layer Equations

Essential Reading:

1. G. K. Batchelor, *An Introduction to Fluid Dynamics*, Cambridge University Press, 1993.

Supplementary Reading:

1. N. Curle and H. Davies, *Modern Fluid Dynamics*, Van Nostrand Reinhold, 1966.
2. F. Chorlton, *A Text Book of Fluid Dynamics*, Von Nostrand Reinhold/CBS, 1985.
3. L. M. Milne Thomson, *Theoretical Hydrodynamics*, Macmillan and Co., 1960.
4. A. R. Patterson, *A First Course in Fluid Dynamics*, Cambridge University Press, 1992.

MA 539 SCIENTIFIC COMPUTATING 4 credits [3-1-0]

Errors; Iterative methods for nonlinear equations; Polynomial interpolation, Spline interpolations; Numerical integration based on interpolation, quadrature methods, Gaussian quadrature; Initial value problems for ordinary differential equations - Euler method, Runge-Kutta methods, multi-step methods, predictor-corrector method, stability and convergence analysis; Finite difference schemes for partial differential equations - Explicit and implicit schemes; Consistency, stability and convergence; Stability analysis (matrix method and von Neumann method), Lax equivalence theorem; Finite difference schemes for initial and boundary value problems (FTCS, Backward Euler and Crank-Nicolson schemes, ADI methods, Lax Wendroff method, upwind scheme).

Essential Reading:

1. D. Kincaid and W.Cheney, *Numerical Analysis:Mathematics of Scientific Computing, 3rd Ed*., AMS, 2002.
2. G. D. Smith, *Numerical Solutions of Partial Differential Equations, 3rd Ed.*, Calrendorn Press, 1985.

Supplementary Reading:

1. K. E. Atkinson, *An Introduction to Numerical Analysis*, Wiley, 1989.
2. S. D. Conte , C. de Boor, *Elementary Numerical Analysis, An Algorithmic Approach*, McGraw-Hill, 1981.
3. R.Mitchell and S.D.F.Griffiths, *The Finite Difference Methods in Partial Differential Equations*, Wiley, 1980.

MA 540 SINGULAR HOMOLOGY THEORY 4 credits [3-1-0]

General Homology Theory: Axioms of homology theory, Singular homology theory, Affinely independent, Ordered simplex: Standard n-simplex, Singular n-simplex, singular n-chain, Free abelian group, Singular chain complex, nth singular homology group of a topological space, boundary operator, Induced homomorphism of singular homology groups, Connecting homomorphism, Brouwer fixed point theorem: Brouwer degree, Jordan-Brouwer separation theorem, Brouwer theorem on the invariance domain, Inverse system and direct system of abelian groups, Attaching spaces with maps, Singular homology groups of standard projective spaces: Excision theorem, Reduced singular homology groups, Strong deformation retract, Relative homeomorphim theorem, Verification Eilenberg-Steenrod axioms, Calculation of singular homology groups using Eilenberg-Steenrod axioms, Products: Kunneth formula, Acyclic model Theorem, Homology external product, Alexander-Whitney diagonal approxi-mation, Homology theory of CW-complxes, Some cases application of singular homology groups in electrical engineering.

Essential Reading:

1. J. Rotman: *An Introduction to Algebraic Topology* (Springer-Verlag) 2004

MA 541 COMMUTATIVE ALGEBRA 4 credits [3-1-0]

Dimension theory of affine algebras: Principal ideal theorem, Noether normalization lemma, dimension and transcendence degree, catenary property of affine rings, dimension and degree of the Hilbert polynomial of a graded ring, Nagata's altitude formula, Hilbert's Nullstellensatz, finiteness of integral closure.
Hilbert-Samuel polynomials of modules : Associated primes of modules, degree of the Hilbert polynomial of a graded module, Hilbert series and dimension, Dimension theorem, Hilbert-Samuel multiplicity, associativity for-mula for multiplicity, Complete local rings: Basics of completions, Artin-Rees lemma, associated graded rings of filtrations, completions of modules, regular local rings Basic Homological algebra: Categories and functors, derived functors, Hom and tensor products, long

exact sequence of homology modules, free resolutions, Tor and Ext, Koszul complexes. Cohen-Macaulay rings: Regular sequences, quasi-regular sequences, Ext and depth, grade of a module, Ischebeck's theorem, Basic properties of Cohen-Macaulay rings, Macaulay's unmixed theorem, Hilbert-Samuel multiplicity and Cohen-Macaulay rings, rings of invariants of finite groups.

Essential Reading:

1. D. Eisenbud, Commutative Algebra (with a view toward algebraic geometry) Graduate Texts in mathematics 150, Springer-Verlag, Berlin, 2003.

Supplementary Reading:

2. H. Matsumura, Commutative ring theory, Cambridge Studies in Advanced Mathematics No. 8, Cambridge University Press, Cambridge, 1980.

3. W. Bruns and J. Herzog, Cohen-Macaulay Rings, (Revised edition) Cambridge Studies in Advanced Mathematics No. 39, Cambridge University Press, Cambridge, 1998.

MA 542 TENSOR ANALYSIS 4 credits [3-1-0]

Tensor analysis: Transformation of coordinates, The summation convention, Contravariant vectors, Invariants, Covariant vectors, Tensors, The Christofell 3-index symbols and their relations, Riemann symbols and the Riemann tensor, The Ricci tensor, Quadratic differential forms, The equivalence of symmetric quadratic differential forms, Covariant differentiation with respect to a tensor g_{ij}, Introduction to a metric: Definition of a metric, N-tuply orthogonal systems of hypersurfaces in a V_n, Metric properties of a space V_n immersed in a V_m, Geodesics, Riemannian, Normal and geodesic coordinates, Geodesic form of the linear element, Finite equations of geodesics, Curvature of a curve, Parallel displacement and the Riemann tensor, Fields of parallel vectors, Associate directions, Curvature of V_n at appoint, The Bianchi identity, The theorem of Schur, Isometric correspondence of spaces of constant curvature, Conformal spaces, Spaces conformal to flat space, Orthogonal ennuples: The Frenet formulas Principal directions determined by a symmetric covariant tensor of the second order, The Ricci principal tensors, Condition that a congruence of an orthogonal ennuple be normal, N-tuply orthogonal systems of hypersurfaces, N-tuply orthogonal systems of hypersurfaces in a space conformal to a flat space, Congruence canonical with respect to a given congruence, Recent developments.

Essential Reading:

1. L.P. Lebedev: *Tensor Analysis* (World Scientific) 2003.

MA 543 COMPLEX DYNAMICS 4 credits [3-1-0]

1. Introduction and definitions
2. Newton's method
3. Critical points, classification of fixed points, periodic points
4. The Fatou and Julia sets
5. Properties of the Julia set
6. Repelling and parabolic fixed points
7. Connectedness, density of orbits
8. Classification of components of the Fatou set
9. No wandering domains
10. Attracting basins, rotation domains
11. Bottcher's theorem
12. Shishikura's theorem
13. Quadratic polynomials
14. The special case of polynomials, quadratic polynomials
15. The structure of the Fatou sets

16. The Mandelbrot set (the parameter space)- Definition and properties, Proof that its complement is simply connected (time permitting), Its interior structure; combinatorics

Essential Reading:

1. Iteration of rational functions, Alan F. Beardon

MA 544 CATEGORY THEORY 4 credits [3-1-0]

Categories and Functors: The definition of a category, Covariant and contravariant functors, Natural transformations, Natural equivalence, Examples from from different topics of engineering and sciences, The duality principle, The construct of small categories, Reflective subcategories, Coma category, Full and faithful functors, Limits and colimits: Products and coproducts, Limits, colimits, equalizer, coequaliser, pullback, pushout, Universal and couniversal properties, Equivalence of equalizer and pullback in presence of products, Equivalence of coequalizer and pushout in presence coproducts, Limits in terms of products and equalizers, Limits in terms of products and pullback, Colimits in terms of coproducts and coequalizers, Colimits in terms of coproducts and pushout, Adjoint functors: Left adjoint, Right adjoint, Adjoint functor theorem, Preservation of limits by adjoint functors, Representable functors, Representing objects, Tensor products of categories.

Essential Reading:

1. S. Awodey: *Category Theory* (Oxford University Press) 2006

MA 545 CONVEX ANALYSIS AND MONOTONE OPERATORS 4 credits [3-1-0]

Convex set, convex function and its properties in Banach spaces and R^n, Subdifferential, Normal and tangent cones and its application to optimization, Fenchel duality, Clarke subdifferential, cone and its properties, Regular normal cone, subdifferential, subderivatives and its calculus rule in R^n.

Monotone operators: definitions, examples, properties, Fitzpatrick's function: definition and properties, Linear maximal monotone operators, Maximal monotonicity of sums and compositions involving maximal monotone operators in reflexive spaces and non reflexive spaces, Introduction of different types of maximal monotone operators and its relationship, Enlargements of monotone operators.

Essential Reading:

1. Rockafellar and Wets, *Variational Analysis* , Springer, Chapter-: 2 (A, B, D,E, F), 6(A,B) and 8(A,B,C).

Supplementary Reading:

1. J. M. Borwein and A. S. Lewis, *Convex Analysis and Nonlinear Optimization Theory and Applications*, Springer, Chapter-: 3 and 6
2. F H Clarke, *Optimization and Nonsmooth analysis*, Chapter-: 1.1,1.2,2.1,2.2 and 2.3.
3. S Simons, *Hahn Banach to Monotonicity*, Springer, Chapter-: IV, VI and VII

MA 546 DIFFERENTIABLE MANIFOLDS 4 credits [3-1-0]

Differentiable Manifolds: Topological manifolds, Chart, Atlas, Maximal atlas, Differentiable structures, Differentiable functions, Diffeomorphisms, Germs of local smooth functions, Algebra of smooth germs, Derivation, Tangent and cotangent spaces, Differential of smooth map, Immersion, Vector bundles, Examples of smooth vector bundles, Differential forms: Alternate k-linear functions, Grassmann algebras, Universal property of exterior algebra, Differential forms, Differential k-forms, Exterior multiplication, Exterior differentiation, De Rham cohomolgy groups, Induced transformations, Poincare's lemma, Riemannian manifolds: Innerproducts, Riemannian structures, Riemannian metric, Riemannian connection, Geodesics, Convex neighborhoods, De Rahm's theorem: Singular homology groups, Real singular cohomology groups, De Rham's theorem.

Essential Reading:

1. L. Conlon: *Differentiable Manifolds* (Springer-Verlag): 2001

MA 547 GEOMETRY OF NORMED SPACES 4 credits [3-1-0]

Geometric form of Hahn-Banach theorem, w-w* topologies, James characterization of reflexivity, Strict convexity, Uniform convexity, Duality between strict convexity and smoothness, Differentiability of the norm, Drop theorem, Bishop- Phelp theorems, Krein-Milman theorem and Radon-Nikodym property

Essential Reading:

1 M. Fabian, P. Habala, P. Hajek, V.M. Santalucia, J. Pelant and V. Zizler, Functional analysis and infinite dimensional geometry, Canadian Mathematical Society, 2001

Supplementary Reading:

1. J. B. Conway, *A course in functional analysis*. Graduate Texts in Mathematics, 96. Springer-Verlag, 1990.
2. K. Yosida, *Functional Analysis*, Springer-Verlag (1980).

MA 548 FIELD THEORY 4 credits [3-1-0]

Algebraic Extensions, Algebraic closed fields, Splitting fields, Normal extensions, Multiple Roots, Finite fields, Separable extensions, Galois theory: Automorphism groups and fixed firelds, Fundamental theorem of Galois theory, Fundamental theorem of algebra, Applications: Roots of unity and cyclotomic polynomials, cyclic extensions, Polynomoals solvable by radicals, Symmetric functions, Ruler and compass construction

Essential Reading:

1. S. Lang: *Algebra* (Addison-Wesley)
2. T. W. Hungerford: *Algebra* (Springer)

MA 549 ALGEBRAIC GEOMETRY 4 credits [3-1-0]

Regular Functions and Maps: The Zariski topology, Regular functions on an affine variety, Projective varieties, Regular maps, The Veronese map, Determinantal representation of Veronese varieties, Subvarieties of Veronese varieties, The Segre maps, Subvarieties of Segre varieties, Products of varieties, Graphs, Fiber products, Combinations of Veronese and Segre maps, Cones, Projections and More about Products: Cones, Quadrics, Projections, More cones, More projections, Constructible sets, Families and parameter spaces: Families of varieties, The universal hyperplane, The universal hyper section, Parameter spaces of hypersurfaces, Universal families of hypersurfaces, A family of lines, Rational functions and rational maps: Rational functions, Rational Maps, Graphs of Rational Maps, Birational Isomorphism, The Quadric Surface, Hypersurfaces, Degree of a rational map, Blow-ups, Blowing up points, Blowing up subvarieties, The quadric surface again, The cubic scroll in $\mathbb{P}^4$, Unirationality.

Essential Reading:

1. J. Harris, *Algebraic Geometry A First Course*, Springer, 1992

MA 550 CODING THEORY 4 credits [3-1-0]

Block codes, Linear codes, Hamming codes, Weight enumerators, Binary Golay code, Ternary Golay code, Constructing codes from other codes, Ree-Muller codes, Cyclic codes: Generator matrix and check polynomial, Zeros of a cyclic code, BCH codes, Reed-Solomon codes, Binary cyclic codes of length 2n (n odd).

Essential Reading:

1. J. H. van Lint, *Introduction to Coding Theory*, Springer, 1998.
2. F. Blake & R. C. Mullin, *An introduction to Algebraic and Combinatorial Coding theory,* Academic press, 1976.

MA 551 NUMERICAL ANALYSIS 4 credits [3-1-0]

Sources of errors, Propagation of errors, Stability in numerical analysis, Root finding of nonlinear for equations: Aitken extrapolation for linearly convergent sequences, Error tests, The numerical evaluation of multiple roots, Brent's root finding algorithm, Hermite interpolation, Piecewise polynomial interpolation, The minimax and near minimax approximations, The Remes algorithms, Numerical integration: Patterson's method, Asymptotic error formulas and their applications, Adaptive numerical integration, Singular integrals, Umerical methods for differential equations: Multistep method, Derivation of higher-order multistep methods, Numerical solutions of system of linear equations: The residual correction method, Error prediction and acceleration, The numerical solution of Poisson's equation.

Essential Reading:

1. K. E. Atkinsan, *An Introduction to Numerical Analysis*, Willey, 1978
2. E. Süli, D. F. Mayers, *An Introduction to Numerical Analysis*, Cambrige University Press, 2003

MA 552 FUZZY LOGIC AND SET THEORY 4 credits [3-1-0]

Fuzzy sets, Support, Membership function, Fuzzy union and intersection, Fuzzy product, Fuzzy topological spaces, Fuzzy continuity, Fuzzy compactness, Fuzzy connectedness, Fuzzy groups, Fuzzy normal Subgroups, Fuzzy ideals, Fuzzy maximal ideals.

Essential Reading:

1. H. J. Zimmermann, *Fuzzy Set Theory and Its Applications*, Kluwer Academic Publishers, 1998.

MA 553 OPTIMIZATION TECHNIQUES 4 credits [3-1-0]

Dynamic programming: Introduction, The recursive equation approach, Computational proce-dure in dynamic programming, Solution of LPP by dynamic programming, Application of dynamic programming to a minimum path problem, Goal programming: Goal programming problem, Generalized goal programming models, Chebyshev norm model, Network optimization problem: The shortest-path problem, The mimimun spanning tree problem, Maximum flow problem, Minimum cost flow problem, Network simplex method, Simulation: Various Methods of Sample Collection, Simulated sampling (Monte-Carlo method), Definition of simulation, Steps in simulation procedure, Simulation model, Application of simulation method, Simulations here Monte-Carlo methods are useful, General procedure of Monte Carlo methods, Advantages and disadvantages of Monte Carlo methods, Problem of Replacement: Replacement models and their solutions, Concept of present value, Replacement of items whose efficiency deteriorates with time, Replacement of items whose maintenance cost increases with time and the value of money remains the same, Replacement of items when value of money also changes, Replacement of items that fail completely, Group replacement method, Inventory control: Economic lot size models, EOQ with uniform rate of demand, Economic lot size with different rates of demand in different cycles, Determination of buffer stock, ABC analysis of inventory, Game theory: Solving simple games, Games with mixed strategies, Graphical solution procedure, Solution by linear programming.

Essential Reading:

1. F. S. Hillier & G. J. Lieberman, *Introduction to Operations Research*, Tata McGraw-Hill, 2005

Supplementary Reading:

1. N.S. Kambo, *Mathematical Programming Techniques*, Affiliated East-West Press Ltd, 1984.

MA 554 GRAPH THEORY WITH ALGORITHMS 4 credits [3-1-0]

Introduction to Graphs, Isomorphism, Bipartite graphs, Directed graphs, Subgraphs, Spanning Subgraphs (Super graphs), Operations on graphs, Walk, Trails and Paths, Connected graphs, Disconnected graphs, Cycles, Euler Tour, Euler Trail, Euler graphs, Euler Theorem, Hamiltonian path, Hamiltonian graphs, Maximal non-Hamiltonian graphs, Dirac's Theorem, Ore's Theorem, Complement graph, Trees, Spanning Tress, Fundamental Circuits, Fundamental Cutsets, Algorithms on graphs, Shortest path Algorithms: Dijkstra's Algorithm, Floyd-Warshall's Algorithm, Minimal Spanning Tree, Breadth First Search Algorithm, Depth First Search Algorithm, Matrix Representation of graphs, Incidence matrix, Adjacency Matrix, Circuit Matrix, Vector Space associated with graphs, Cut sets, Cut vertices, Edge connectivity, Vertex connectivity, Whitney's Inequality, Coloring of graph, Chromatic number, Chromatic polynomial, Edge contraction, Plane and Planar graphs, Embedding and Regions, Kuratowski's Two graphs K_5 and $K_{3,3}$, Euler's Formula, Subdivision and Branch vertex, Kuratowski's Theorem, Dual of a planar graph, Edge Coloring, Edge Chromatic number, Coloring planar graphs, The Four-Color Theorem, The Five-Color Theorem, Map Coloring, Network Flows, Transport networks and cuts, Maxflow-Mincut Theorem, Residual capacity and Residual network, Ford-Fulkerson Algorithm, Edmonds-Karp Algorithm, Maximal Flow Applications, Multiple sources and sinks, Maximum Bipartite matching.

Essential Reading:

1. S. Saha Ray, Graph Theory with Algorithms and Its Applications in Applied Science and Technology, Springer, 2012.

Supplementary Reading (Reference Books):

1. N. Deo, *Graph Theory with Applications to Engineering and Computer Science,* PHI, 1974.

MA 555 STOCHASTIC PROCESSES 4 credits [3-1-0]

Stochastic Processes: Definition and examples of stochastic processes, Classifications of stochastic processes, Markov chains: Definition and examples, Transition Probability matrices, Classification of states of a Markov chain, Determination of higher order transition probabilities, Stability of a Markov chain, Graph theoretic approach, Markov chains with denumerable number of states, Reducible Markov chains, Markov Chains with continuous state spaces, Non-homogeneous Markov Chains, Markov chains in continuous time: General pure birth and death processes, Birth and death processes with absorbing states, Renewal processes: Renewal processes in continuous time, renewal equation, Renewal theorems, Residual and excess lifetime, Renewal reward processes, Regenerative renewal processes, Regenerative inventory systems, Generalization of the classical renewal theory, Stochastic processes in queuing and reliability: General concepts of queuing systems, Steady state and transient behavior, Birth and death process in queuing theory, Network of Markovian queuing systems, Reliability, Introduction to Brownian motion: Wiener processes, Differential equations for a Wiener process, Kalmogrov's equations, The first passage time distribution for a Wiener process. Recent developments.

Essential Reading:

1. J. Medhi, *Stochastic Processes*, New Age Publishers, Second Edition, Reprint 2007.

Supplementary Reading:

1. S. Karlin and H. M. Taylor, *A First Course in Stochastic Processes*, Academic Press, 1975.

MA 556 NUMBER THEORY 4 credits [3-1-0]

Basis representation: Principles of mathematical induction, The basis representation theorem, *The fundamental theorem of arithmetic*: Euclid's division lemma, Divisibility, The linear Diophantine equation, The fundamental theorem of arithmetic, Combinatorial and computational number theory: Fermat's little theorem, Wilson's theorem, Generating functions, The use of computers in number theory, *Fundamentals of congruences*: Basic properties of congruences, Residue systems,

Riffling, *Solving congruences*: Linear congruences, The theorems of Fermat and Wilson revisited, The Chinese remainder theorem, Polynomial congruences, Arithmatic functions: Combinatorial study of $\varphi(n)$, Formulae for d(n) and $\sigma(n)$, Multiplicative arithmetic functions, The Mobius inversion formula, *Primitive roots*: Properties of reduced residue systems, Primitive root modulo p.

Essential Reading:

1. G. E. Andrews, *Number Theory*, Courier Dover Publications, 1994.

MA 557 STATISTICAL INFERNECE (PARAMETRIC) 4 credits [3-1-0]

Parametric models, parameters, random sample and its likelihood, statistic and its sampling distributions, problems of inference. Examples from standard discrete and continuous models such as Bernoulli, Binomial, Poisson, Negative Binomial, Normal, Exponential, Gamma, Weibull, Pareto etc. Concept of sufficiency, minimal sufficiency, Neyman factorization criterion, Fisher information, exponential families. Maximum likelihood estimators, method of moment estimators, percentile estimators, least squares estimators, minimum mean squares estimators, uniformly minimum variance unbiased estimators, Rao-Blackwell theorem, Cramer-Rao lower bond, different examples.

Statistical Hyptheses-simple and composite, statistical tests, critical regions, Type-I and Type-II errors, size and power of a test, Neyman Pearson lemma and its different applications. Most powerful test, uniformly most powerful test, unbiased test and niformly most unbiased test. Likelihood ratio test. Interval estimation, confidence intervals, construction of confidence intervals, shortest expected length confidence interval, most accurate one sided confidence interval and its relation to UMP test.

Essential Eeadings:

1. R. L. Berger and G. Casella, *Statistical Inference.*
2. E. L. Lehmann, *Theory of Point Estimation*

Supplementary Readings:

1. T. S. Ferguson, *Statistical Decision Theory.*
2. E. L. Lehmann, *Testing of Statistical Hypotheses.*
3. P. J. Bickel and K. A. Doksum, *Mathematical Statistics.*
4. J. O. Berger, *Statistical Decision* Theory.

MA 558 SAMPLING TECHNIQUES 4 credits [3-1-0]

Basic concept of sample surveys: Census and sample surveys, Advantages and disadvantages, Probability and non-probability sampling, Sampling unit, Sampling frame, Sampling and non-sampling error, Simple random sampling and Stratified random sampling: Procedure for selecting a random sample, Estimation of population parameters, Estimation of population Proportion, Confidence limits, Estimation of sample size, Principle of stratification, Advantages of stratification, Estimation of population mean and variance, Allocation of sample size in different strata, Relative precision of stratified random sampling over simple random sampling, Estimation of gain in precision due to stratification, Systematic random sampling: Sample selection procedure, Advantages and disadvantages, Estimation mean and its sampling variance, Comparison of simple random sampling with stratified random sampling in some specified populations, Cluster sampling: Equal cluster sampling, Estimator of mean and its variance, Relative efficiency of cluster sampling, Optimum cluster size, Cluster sampling for proportions.

Essential Reading:

1. R.K.Som, *Practical Sampling Techniques*, CRC Press, 1995

Supplementary Reading:

1. S.K. Thompson, *Sampling*, John Wiley, 1992.

MA 559 STATISTICAL DECISION THEORY 4 credits [3-1-0]

Games and statistical games, statistical decision problem, decision funcion, risk function, prior and posterior distribution, Bayes risk and Bayes rules, least favourable prior, minimaxity, admissibility and complete classes, admissibility of Bayes rules, existence of minimal complete class and Bayes rules, the supporting and separating hyperplane theorems, essential completeness of the class of nonrandomized rules, minimax and complete class theorems, solving for minimax rules, essential completeness of class of rules based on suffiecient statistics, continuity of risk functions, invariant decision problems, admissible and minimax invariant decision rules.

Essential Readings:

1. T. S. Ferguson, *Statistical Decision Theory.*
2. E. L. Lehmann, *Theory of Point Estimation.*

Supplementary Readings:

1. J. O. Berger, *Statistical Decision* Theory.

MA 560 MATHEMATICAL METHODS 4 credits [3-1-0]

Asymptotic expansions, Watson's lemma, method of stationary phase and saddle point method. Applications. to differential equations. Behaviour of solutions near an irregular singular point, Stoke's phenomenon, Method of strained coordinates and matched asymptotic expansions. Variational principles, Lax-Milgram theorem and applications to boundary value problem, Calculus of variations and integral equations. Volterra integral equations of first and second kind. Iterative methods and Neumann series.

Essentials Reading:

1. C.M. Bender and S.A. Orszag, *Advanced Mathematical Methods for Scientists and Engineers*, McGraw-Hill Book Co., 1978.

Supplementary Reading:

1. J. Kevorkian and J.D. Cole, *Perturbation Methods in Applied Mathematics,* Springer Verlag, Berlin, 1985

MA 561 LIE GROUPS AND APPLICATIONS TO ODEs AND PDEs 4 credits [3-1-0]

Lie group of transformations, Infinitesimal transformations, Extended transformations, Multiparameter, Lie group of Transformations, Invariance of Ordinary Differential Equations, Invariance of ODEs under multi-parameter groups, Applications to Boundary Value problems, Invariance of Partial Differential Equations.

Essential Reading:

1.G.W. BIuman and S. Kumei, *Symmetries and Differential Equations*, Springer Verlag, New York, 1989

Supplementary Reading:

2. N.H. Ibragimov, *Transformation groups applied to mathematical physics*, Reidel, Dordrecht, 1985

MA 562 FINITE VOLUME METHODS FOR HYPERBOLIC PDEs 4 credits [3-1-0]

Conservation Laws and Differential Equations, Characteristics and Riemann Problems for Linear Hyperbolic Equations, Finite volume methods, Necessary components for convergence, CFL Condition, Lax-Friedrichs Method, The Richtmyer Two-Step Lax-Wendroff Method, Upwind

Methods, Godunov's Method, Flux-Difference vs. Flux-Vector Splitting, Roe's Method, The Lax-Wendroff Method, The Beam-Warming Method.

Essential Reading:

1. R.J. LeVeque, *Finite volume methods for hyperbolic problems*, Cambridge University Press, Cambridge, UK 2002.

Supplementary Reading:

1. E. F. Toro, *Rieman solvers for numerical methods for fluid dynamics*, Springer-Verlag, Berlin, 1999.

MA 563 WAVELETS AND APPLICATIONS 4 credits [3-1-0]

Fourier transform on L^1 (R) and L^2 (R) and basic properties and examples; Motivation and definition of Windowed Fourier Transform and examples, Time frequency localization, the reconstruction formula; Motivation and Definition of the wavelet transform and examples, Basic properties, The reconstruction formula, Frequency localization, Scaling functions and wavelets, orthogonal bases of compactly supported wavelets, orthonormal Wavelets; Definition of Multiresolution Analysis and examples, Properties of scaling functions and orthonormal wavelets bases, Construction of orthonormal wavelets.

Essential Reading:

1. L. Debnath, *Wavelet Transforms and Their Applications*, Birkhäuser, 2002.

Supplementary Reading:

1. G. Bachman, L. Narici, and E. Beckensterin, *Fourier and Wavelet Analysis*, Springer-Verlage, 2000.

2. C.K. Chui, *An Introduction to Wavelets*, Academic Press, 1992.

MA 564 INTEGRAL AND DESCRETE TRANSFORMS 4 credits [3-1-0]

Laplace Transform : Definition - Functions of exponential order and examples - Transforms of elementary, transcendental and special functions - transforms of derivatives and integrals and periodic function, unit step function and impulse function - The inverse transform - Convolution theorem - solution of differential equations by the use of the transform - Laplace inverse integral - Solution of Laplace equation (in two dimensions), one dimensional heat equation and one dimensional wave equation.

Fourier transform : The Fourier transform, Inverse Fourier transform, Fourier transform properties, Convolution integral, convolution theorem, correlation, correlation theorem, Parseval's theorem, Wave from sampling, sampling theorem, frequency sampling theorem, Solution of one dimensional heat equation. Discrete Fourier Transform : Fourier transform of sequences, Discrete Fourier transform, transfer function. The Fast Fourier Transform : Intuitive Development, Theoretical development of Base 2, FFT algorithm.

Z transform : Z transform, inverse Z transform, Z transform properties, solution of linear difference equations by using z-transform.

Mellin Transforms: Definition, properties and evaluation of transforms, Convolution theorem for Mellin transforms, Application to integral equations.

Essential Reading :

1. Churchill, *Operational Mathematics*, McGraw Hill, Tokyo, 1972.
2. Hildebrand, *Methods of Applied Mathematics*, Prentice Hall Inc., New Jercy, 1960.

3. E.O.Brigham, *The Fast Fourier Transforms*, Prentice Hall, 1988.
4. E.J.Jerry, *Theory and applications of Z transform method*, 1996.

MA 565 FRACTIONAL ORDER CALCULUS 4 credits [3-1-0]

Special Functions of the Fractional Calculus: Gamma Function. Mittag-Leffler Function. Wright Function. **Fractional Derivatives and Integrals:** Grünwald-Letnikov Fractional Derivatives. Riemann-Liouville Fractional Derivatives. Some Other Approaches. Geometric and Physical interpretation of Fractional Integration and Fractional Differentiation. Sequential Fractional Derivatives. Left and Right Fractional Derivatives. Properties of Fractional Derivatives. Laplace Transforms of Fractional Derivatives. Fourier Transforms of Fractional Derivatives. Mellin Transforms of Fractional Derivatives. **Fractional Green's Function**: Definition and some properties. One Term Equation. Two Term Equation, Three-Term Equation, Four-Term Equation. General Case: n-term Equation. **Numerical Evaluation of Fractional Derivatives:** Approximation of Fractional Derivatives. The "Short-Memory" Principle. Order of Approximation. Computation of Coefficients. Higher-order Approximations.

Essential Reading:

1. I. Podlubny, Fractional Differential Equations, San Diego, Academic Press, 1999.

Supplementary Reading:

1. K. S. Miller and B. Ross, An Introduction to the fractional calculus, New York, John Wiley 1993.
2. S. G. Samko, A. A. Kilbas, and O. I. Marichev, Fractional Integrals and Derivatives: Theory and Applications, Taylor & Francis Books Ltd, London, 2002.
3. K. B. Oldham and J. Spanier, The Fractional Calculus: Theory and Applications of Differentiation and Integration to Arbitrary Order, Academic Press, New York, 1974.
4. Carpinteri and F. Mainardi (Editors), Fractals and Fractional Calculus in Continuum Mechanics. CISM Courses and Lectures no. 378. International Centre for Mechanical Sciences. Springer Verlag Wien, New York, 1997.

MA 566 FRACTIONAL DIFFERENTIAL EQUATIONS AND FRACTIONAL ORDER MODELS 4 credits [3-1-0]

Linear Fractional Differential Equations: Fractional Differential Equation of a General Form. Existence and Uniqueness theorem as a method of solution. Dependence of a solution on initial conditions. The Laplace Transform method. Standard Fractional Differential Equations. Sequential Fractional Differential Equations. **Some Methods for the solution of Fractional-order Equations:** Power Series Method. Babenko's Symbolic Calculus method. Method of Orthogonal Polynomials. The Mellin Transform Method. **Numerical Solution of Fractional Differential Equations:** Initial value problems and Boundary value problems for linear equations. Examples of Numerical Solutions. The "Short Memory" Principle in Initial Values problems for Fractional Differential Equations. Matrix approach to discrete fractional calculus. Numerical solution of nonlinear problems. **Applications:** Fractional order models. Fractional order systems and controllers.

Essential Reading:

1. I. Podlubny, Fractional Differential Equations, San Diego, Academic Press, 1999.

Supplementary Reading:

1. K. S. Miller and B. Ross, An Introduction to the fractional calculus, New York, John Wiley 1993.
2. K. Diethelm, The Analysis of Fractional Differential Equations, Springer-Verlag, Berlin, Germany, 2010.

3. K. B. Oldham and J. Spanier, The Fractional Calculus: Theory and Applications of Differentiation and Integration to Arbitrary Order, Academic Press, New York, 1974.
4. A. Carpinteri and F. Mainardi (Editors), Fractals and Fractional Calculus in Continuum Mechanics. CISM Courses and Lectures no. 378. International Centre for Mechanical Sciences. Springer Verlag Wien, New York, 1997.

MA 567 THEORY OF VIBRATIONS 4 credits [3-1-0]

Theory of Vibrations: Vibrations Basics, One Degree of Freedom Systems, Two Degree of Freedom System, Multi-Degree of Freedom Systems, Continuous Systems: String, Rod, Beam, Membrane, Plate, Equation of Motion Through application of energy method, Approximate methods for Vibrations problems, Rayleigh methods, Rayleigh-ritz methods, Non-Linear Vibarion.

Essential Reading:

1. Inman D.J 1994. *Engineering Vibrations*. Prentice Hall, Englewood Cliffs, NJ.
2. Timoshenk S., Young D.H. and Weaver W. 1990. *Vibrations Problems in Engineering* 5th ed. Wiley, New York., NY.
3. Rao J.S. *Advanced Theory of Vibration*. New York, NY1991.
4. Chakraverty S *Vibration of Plates*, Taylor and Francis, Boka Raton. 2008.
5. Meirovitch L. *Elements of Vibration Analysis*. 2nd Ed. McGraw Hill, New York, NY1986.

MA 568 MATHEMATICS OF SOFT COMPUTING 4 credits [3-1-0]

Introduction to soft computing, Fuzzy set theory, Fuzzy logic and control, gradient descent optimization: least squares methods, genetic algorithms, swarm optimization, support vector machines, neural networks: supervised and unsupervised learning: Hopfield nets, perceptrons, gradient descent, multilayer nets, backpropagation, overfitting, hybrid systems: neuro-fuzzy, neuro-genetic, GA tuned Fuzzy system.

Essential Readings:

1. J-S.R Jang, C-T. Sun, E. Mizutani, Neuro-Fuzzy and soft computing" Prentice Halls, 1997.
2. Ross T J., Fuzzy Logic with engineering applications, John Wiley & Sons 2007.
3. RA Aliev & RR Aliev Soft Computing and its applications, World Scientific, 2001.
4. JM Zurada, Introduction to Artificial Neural Systems. West Pub. Company, 1992
5. John Shawe-Taylor & Nello Cristianini, Support Vector Machines and other kernel – based learning methods- Cambridge University Press, 2000.

MA 569 PERTURBATION METHODS 4 credits [3-1-0]

Asymptotic expansion and approximation, asymptotic solution of algebraic and transcendental equations, regular and singular perturbations for first and second-order ordinary differential equations, physical examples, initial-value problems, multiple scales, two-scale asymptotic approximation, averaging technique, composite asymptotic expansions, initial layers - matching by Van Dyke rules. Two-point boundary-value problems: Boundary layers -exponential and cusp layers, matched asymptotic expansions, composite asymptotic expansions, WKB (Wentzel, Kramers, Brillouin) expansion method, conditions for validity of the WKB approximation, patched asymptotic approximations, WKB solution of inhomogeneous ordinary differential equations. Perturbation methods for linear eigen value problems, Rayleigh-Schrodinger theory, singularity structure of eigen values as functions of complex perturbing parameter, level crossing. Nonlinear eigen value problems, direct error estimation, oscillatory phenomena - free conservative and free self-sustained oscillations, harmonic resonance, shock and transition layers.

Essential Readings:

1. C.M. Bender, S.A. Orszag, *Advanced Mathematical Methods for Scientists and Engineers*, Springer, New York, 1999.
2. W. Eckhaus, *Asymptotic Analysis of Singular Perturbations*, North-Holland, Amsterdam, 1979.
3. J. Kevorkian, J.D. Cole, *Perturbation Methods in Applied Mathematics*, Springer- Verlag, New York, 1981.
4. P.A. Lagerstrom, *Matched Asymptotic Expansions*, Springer-Verlag, New York, 1988.
5. J. A. Murdock, *Perturbations -Theory and Methods*, SIAM -Classics in Applied Mathematics, Vol. 27, SIAM, Philadelphia, 1999.
6. A.H. Nayfeh, *Introduction to Perturbation Techniques*, John Wiley & Sons, New York, 1981.
7. R.E. O'Malley, *Singular Perturbation Methods for Ordinary Differential Equations*, Springer-Verlag, New York, 1991.

MA 571 STATISTICAL METHODS LABORATORY 2 credits [0-0-3]

Computational works are to be done on the following topics.

1. Calculation of A.M., G.M., H.M., median and mode
2. Calculation of quartiles, deciles and percentiles
3. Calculation of range, quartile deviation, mean deviation, standard deviation and root mean square deviations
4. Calculation of central moments from raw moments, calculation of skewness and kurtosis
5. Calculation of raw moments from central moments, calculation of moments about one point from moments about another point
6. Flitting of binomial distribution
7. Flitting of Poisson distribution
8. Flitting of normal distribution
9. Tasting of hypothesis based on normal distribution
10. Tests based on chi-square distribution
11. Tests based on t-distribution
12. Tests based on F-distribution

MA 572 LABORATORY WORKS ON REAL LIFE PROBLEMS – II 2 credits [0-0-3]

MA 574 LABORATORY WORKS ON NSPDE 2 credits [0-0-3]

Finite difference methods for Parabolic, Elliptic and Hyperbolic equations using explicit and Implicit Schemes - Consistency, Stability and Convergence analysis.

DEPARTMENT OF PHYSICS

DETAILED SYLLABI OF COURSES

Sub. Code	Subject	L-T-P	Credits
PH 101	Physics – I	3-1-0	4
PH 102	Physics - II	3-1-0	4
PH 170	Physics Laboratory	0-0-3	2
PH 201	Thermodynamics	3-1-0	4
PH 202	Electricity & Magnetism	3-1-0	4
PH 271	Thermal Laboratory	0-0-3	2
PH 272	Electricity & Magnetism Laboratory	0-0-3	2
PH 301	Wave and Oscillations	3-1-0	4
PH 302	Properties of Matter	3-1-0	4
PH 303	Optics	3-1-0	4
PH 304	Introduction to Mechanics	3-1-0	4
PH 311	Fundamentals of Thermal & Statistical Physics	3-0-0	3
PH 312	The Physics of Quantum World	3-0-0	3
PH 321	Physics of Semiconducting Materials	3-0-0	3
PH 331	World of LASERS	3-0-0	3
PH 332	Physics of the Universe	3-0-0	3
PH 341	Treatise of Einstein Work and Beyond	3-0-0	3
PH 351	Science of Nano-materials	3-0-0	3
PH 352	X-Ray techniques for Structure Evaluation	3-0-0	3
PH 371	Waves and Optics Laboratory	0-0-3	2
PH 372	Properties of Matter Laboratory	0-0-3	2
PH 401	Mathematical Methods in Physics	3-1-0	4
PH 402	Numerical Techniques in Physics	3-1-0	4
PH 403	Classical Mechanics	3-1-0	4
PH 404	Electrodynamics	3-1-0	4
PH 405	Statistical Mechanics	3-1-0	4
PH 406	Condensed Matter Physics	3-1-0	4
PH 407	Quantum Mechanics - I	3-1-0	4
PH 408	Quantum Mechanics - II	3-1-0	4
PH 409	Introduction to Spectroscopy	3-1-0	4
PH 422	Theory & Simulation of Nanostructures	3-0-0	3
PH 431	Non-linear systems & Chaos	3-0-0	3
PH 462	Vacuum Science and Applications	3-0-0	3
PH 471	General Physics Laboratory	0-0-3	2
PH 472	Solid State Physics Laboratory	0-0-3	2
PH 473	Spectroscopy Laboratory	0-0-3	2
PH 481	Research Project – I	0-0-6	4
PH 482	Research Project – II	0-0-6	4
PH 507	Nuclear & Particle Physics	3-1-0	4
PH 508	Atomic & Molecular Physics	3-1-0	4
PH 511	Advanced Quantum Mechanics	3-1-0	4
PH 512	Advanced Statistical Mechanics	3-1-0	4
PH 513	Density Functional Theory and its Recent Applications	3-1-0	4
PH 514	Advanced Condensed Matter Physics	3-1-0	4
PH 522	Physics of Semiconductors : from Bulk to quantum dots	3-1-0	4
PH 523	Semiconductor Spintronics & Quantum Computation	3-1-0	4
PH 524	Computational Condensed Matter Physics	3-1-0	4

PH 525	Electronic Structure of Disordered Alloys	3-1-0	4
PH 531	Non-Linear dynamics, Chaos & its recent applications	3-1-0	4
PH 532	Physics of Macromolecules	3-1-0	4
PH 533	Synchronizations & its recent applications in Chaotic Systems	3-1-0	4
PH 535	LASER Physics	3-1-0	4
PH 538	Special Topics in Condensed Matter Physics - I	3-1-0	4
PH 539	Special Topics in Condensed Matter Physics - II	3-1-0	4
PH 541	Dielectric & Magnetic Properties of Materials	3-1-0	4
PH 542	Physics & Applications of Dielectric Materials	3-1-0	4
PH 543	Bio-Ceramic Materials & Applications	3-1-0	4
PH 544	Polymer Physics	3-1-0	4
PH 551	Crystal Symmetry & Crystal Physics	3-1-0	4
PH 553	Advanced X-rays structure analysis	3-1-0	4
PH 554	Physics of Thin Film Technology	3-1-0	4
PH 555	Physics of material synthesis & Charaterization	3-1-0	4
PH 556	X-rays and Nano-Science	3-1-0	4
PH 558	Special Topics in Functional Materials – I	3-1-0	4
PH 559	Special Topics in Functional Materials – II	3-1-0	4
PH 561	Physics of Microelectronic and Photonic Devises	3-1-0	4
PH 562	Superfluidity and Superconductivity	3-1-0	4
PH 563	Physical Phenomena at Low Temperature	3-1-0	4
PH 564	Magnetism – Principles & Applications	3-1-0	4
PH 565	Defects in Solids	3-1-0	4
PH 568	Special Topics in Low Temperature Physics – I	3-1-0	4
PH 569	Special Topics in Low Temperature Physics – II	3-1-0	4
PH 571	Instrumentation Laboratory	0-0-3	2
PH 572	Advanced Material Synthesis Laboratory	0-0-3	2
PH 573	Computational Physics Laboratory	0-0-3	2
PH 574	Advanced Characterization Techniques Laboratory	0-0-3	2
PH 581	Research Project – III	0-0-6	4
PH 582	Research Project – IV	0-0-9	6
PH 591	Research Project – I	0-0-6	4
PH 592	Research Project – II	0-0-9	6
PH 593	Seminar & Technical Writing – I	0-0-3	2
PH 594	Seminar & Technical Writing – II	0-0-3	2
PH 595	Short Term Industrial / Research Experience	0-0-0	2
PH 596	Comprehensive Viva-Voice	0-0-0	2

PH 101 PHYSICS – I 4 Credits [3-1-0]

Optics: (i) Inference: Condition for interference, division of wave front (two beam interference). Young's double slit experiment, fringe pattern on transvers and longitudinal planes, intensity distribution, Fresnel's biprism, displacement of fringes, division of amplitude (two beam interference), cosine law, Newton's rings experiment, Michelson Interferometer, fringes of equal inclination and equal thickness. (ii) Diffraction: Fraunhofer diffraction pattern and intensity distribution. (iii) Polarisation: Polarized and un polarized light, production of polarized light, Malu's law, superposition of two disturbances, phenomena of double refraction interference of polarized light, quarter and half wave plates, Nicole prisam. (iv) Electromagnetic Waves: Maxwell's equations in vacuum & medium, eletro magnetic waves and its transverse nature**Relativity:** Reference frames, inertial frames, Michelson-Morley experiment, speed of light, Galilean relativity and transformation, simultaneous events and simultaneity, postulates of relativity, Lorentz transformation, length contraction and time dilation, velocity addition, relativistic momentum, relativistic mass and mass-

energy relation.**Quantum Mechanics:** (i) Particle nature of wave, Black body radiation, photoelectric effect, x-ray diffraction, Compton effect, pair production, photon and gravity. (ii) Wave nature of particle, De Broglie waves, matter waves as group waves, phase velocity & group velocity, particle diffraction & Davison-Germer experiment, uncertainty principle and its application. (iii) Wave equation: probability & wave function, time dependent and time independent Schrodinger equation, eigen value & eigen functions, boundary conditions on wave function, application of Schrodinger equations to one dimensional problem.

Essential Reading:

1. A. Ghatak, *Optics*, Tata-McGraw Hill (2004)
2. A. Beiser, *Concept of Modern Physics (or Perspective of Modern Physics)*, Tata-McGraw Hill) (2005)

Supplementary Reading:

1. R. Resnick, *Relativity*, Wiley Eastern Pvt. Ltd. (2007)
2. Jenkin & White, *Fundamentals of Optics*, McGraw-Hill, 4th Edition
3. D.J. Griffith, *Introduction to Quantum Mechanics* , Pearson (2007)
4. D. J.Griffith, *Introduction to Electrodynamics*, Pearson (2007)

Prerequisite:

PH 102 PHYSICS – II 4 Credits [3-1-0]

Statistical Mechanics: Statistical distributions, Max-B statistics, molecular energies in ideal gas, quantum statistics: B-E & F-D statistics, Rayleigh-Jeans formula, Planck's radiation law, specific heats of solids, free electrons in metals, electron-energy distribution, dying stars. ; **Spectroscopy:** quantum theory of hydrogen atom, quantum number for three dimensions : principal, orbital & magnetic quantum numbers (space quantization), electron probability density, radiative transitions, selection rules, Zeeman effect. Electron spin, exclusion principle, symmetric & anti-symmetric wave functions, atomic structures, spin-orbit coupling, total angular momentum, X-ray spectra. LASER: Coherent time & length (temporal coherence), Line width, spatial coherence(Michelson stellar Interferometer), optical beats, Fourier analysis of Coherence time and line width, visibility in Young's double slits experiment, Fourier transform spectroscopy (introduction). Spontaneous & stimulated emission, metastable states, optical pumping, population inversion, Einstein approach of stimulated emission, Einstein coefficient, components of laser: optical cavity & resonator, optical amplification, Fiber laser, Ruby & He-Ne lasers. ; **The Solid State :** Crystalline & amorphous solids, Crystal structure, Bravais lattice, packing fraction, atomic radius, point defect, dislocations, reciprocal lattice & Brilloin zones, wide & small angles X-ray- crystellography: crystal planes, Bragg's diffraction & diffraction condition in reciprocal lattice, Ionic, metallic, covalent and Van der Waals bonds, nano-tubes. Band theory of solids : formation of allowed & forbidden bands due to periodicity, Kronig-Peny model for periodic potential. Origin of resistivity, effective mass of electron, classification of solids on the basis of band theory, impurity in semiconductors. Dielectric (including ferroelectric & piezoelectyric) & Magnetic properties of solids (dia-, para and ferromagnetism), Langevin theory, Weiss theory of ferromagnetism, hysteresis, superconductivity: zero resistence, type-I & type-II superconductors, magnetic properties of superconductors (Meissner effect), flux quantization & Josephson junction, vacuum science and its application. ; **Nuclear Physics :** Nuclear structure, atomic masses, mass spectrograph, nuclear properties, stable nuclei, binding energy, nuclear models: liquid drop and shell models, meson theory of nuclear forces, cross section, nuclear reactions, nuclear fissions, nuclear reactors, fusion in stars, fusion reactors: energy source for future, constituents of nuclear particles: quarks, hadrons, Glons.

Essential Reading:

1. Ghatak, *Optics*, Tata-McGraw Hill (2004)
2. Beiser, *Concept of Modern Physics (or Perspective of Modern Physics)*, Tata-McGraw Hill) (2005)

Supplementary Reading:

1. C.Kittel, *Introduction to Solid State Physics*, Wiley & Sons (2004)
2. D. J.Griffith, *Introduction to Quantum Mechanics*, Pearson (2007)

Prerequisite: First level Physics course

EC 201 ANALOG ELECTRONICS 4 Credits[3-1-0]

Bipolar Junction Transistor: Review of BJT operation and DC biasing, small signal model, BJT biasing for discrete circuit design, single stage amplifier analysis, complete static characteristic, internal capacitances and second order effect. ***Field-Effect Transistor:*** Review of JFET, depletion and enhancement MOSFET operation, characteristic and DC biasing, MOSFET as amplifier, biasing of MOS amplifier circuits, single stage IC MOS amplifiers, CMOS logic inverter, MOSFET as analog switch, small signal model of MOSFET for high and low frequencies, spice model and analysis of FET circuits. ***Frequency Response Analysis***: S-domain analysis, bode plot, amplifier transfer function, low frequency and high frequency response of common-source and common drain amplifiers, frequency response analysis of other single stage transistor amplifier configuration. ***Feedback Amplifier***: General feed-back structures, negative feedback, the 4 basis feedback topologies and their analysis, close loop gain calculation, amplifier stability analysis using Bode plot.***Output stage and Power Amplifier:*** Classification of output stages, class A, class B, class AB amplifiers, power BJT, IC power transistors and MOS power transistors. ***Differential and Multistage Amplifier:*** BJT differential amplifier, small signal operation of BJT differential amplifier, non-ideal characteristics of differential amplifier, biasing of BJT ICs, multistage amplifiers, spice model and analysis of all circuits.

Essential Reading:

1. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Oxford University Press; 2005.

Supplementary Reading:

1. Spencer and Ghausi, Introduction to Electronic Circuit Design, Pearson Education, 2003
2. A. Dutta, Semiconductor Devices and Circuits, Oxford University Press, ND 2008

PH 201 THERMODYNAMICS 4 Credits[3-1-0]

Concept of thermodynamic state, extensive and intensive variables, Zeroth Law of thermodynamics, measurement of temperature, heat and work, internal energy function and the first law of thermodynamics, ideal gas and gas equations, ideal engine and Carnot cycle, concepts of entropy and temperature as conjugate pair of variables, second law of thermodynamics, entropy maximum and energy minimum principles, entropy, multiplicity and disorder, Maxwell's demon, applications to pure substances, thermodynamic potentials, conditions of equilibrium, concepts of stability, Maxwell's relations, metastable and unstable equilibrium, open systems, components and phases, Joule-Thomson expansion, Gibbs-Duhem relations, first order phase transitions and Clausius-Clapeyron equation, critical phenomena and higher order phase transition, applications for magnetic, dielectric and superconducting systems, heat engines and black body radiation, chemical equilibrium and ideal gas reactions, heterogeneous systems, thermodynamics of irreversible processes, entropy production, kinetic theory of gases, transport phenomena.

Essential Reading:

1. M. W. Zemansky, Heat and Thermodynamics, McGraw-Hill Ltd., 7th Edition, 2007.
2. R. Bowley and M. Sanchez, Introductory Statistical Mechanics, Oxford Press, 2007.

Supplementary Reading:

1. H. B. Callen, Thermodynamics and Thermostatistics, John Wiley & Sons 2nd Ed.
2. L. A. Girifalco, Statistical Mechanics of Solids, Oxford University press, 2000.

3. A. Bieser, Perspective of Modern Physics / Concept of Modern Physics, Tata McGraw-Hill, 2005.

EC 202 DIGITAL ELECTRONICS 3 Credits[3-0-0]

Prerequisites: EC 100: Basic Electronics

Design Concepts: Digital Hardware, Design Process, Hardware, Logic Circuit Design, Theory and Practice; Introduction To Logic Circuits: Variables and Functions, Inversion, Truth Tables, Logic Gates and Networks, Boolean Algebra, Systhesis using AND, OR AND NOT Gates, Design Examples, Introduction to Cad Tools, Introduction to VHDL.; ***Implementation Technology***: Transistor Switches, NMOS Logic Gates, CMOS Logic Gates, Negative Logic System, Standard Chips, Programmable Logic Devices, Custom Chips, Standard Cells and Gate Arrays Practical Aspects, Transmission Gates, Implementation details for FPGAs.; Optimized Implementation of Logic Functions: Karnaugh Map, Strategy for Minimization, Minimization of Product-of-Sums Forms, Incompletely Specified Functions, Multiple-Output Circuits, NAND and NOR Logic Networks, Multi-Level Systhesis, Analysis of Multi-Level Circuits, CAD Tools. ; ***Number Representation and Arithmetic Circuits:*** Positional Number Representation, Addition of Unsigned Numbers, Signed Numbers, Fast Adders, Design of Arithmetic Circuits Using Cad Tools. ; ***Combinational Circuit Building Blocks:*** Multiplexers, Decoders, Encoders, Code Copnverters, Arithmetic Comparison Circuits, VHDL for Combinational Circuits. ; ***Flip-Flops, Registers and Counters, A Simple Processor:*** Basic Latch, Gated SR Latch, Gated D Latch. Master-Slave and Edge-Triggered D Flip-Flops, T Flip-Flop, JK Flip-Flop, Registers, Counters, Reset Synchronization, Other Types of Counters, Using Storage Elements with Cad Tools, Using Registers and Counters With Cad Tools, Design examples. ; Synchronous Sequential Circuits: Basic Design Steps, State Assignment Problem, Meanly State Model, Design of Finite State Machines using CAD Tools, Serial Adder Example, State Minimization, Design of a Counter using the Sequential Circuit Approach, FSM as an Arbiter Circuit, Analysis of Synchronous Sequential Circuits.

Essential Reading:

1. S. Brown and Z. Vranesis, Fundamental of Digital Logic with VHDL design Tata Mc GRAW-Hill, 2003

Supplementary Reading:

1. F. Vahid: Digital Design: Wiley Student Edition, 2006
2. J. F. Wakerly, Digital Design Principles and Practices, Fourth Edition, Prentice-Hall, 2005.
3. R. L. Tokheim, Digital electronics, Principles and applications, 6th Edition, Tata McGraw Hill Edition, 2003

PH 202 ELECTRICITY AND MAGNETISM 4 Credits[3-1-0]

Vectors: Scalar and vector, triple products, differentiation of a vector, ∇ operator, gradient, divergence and curl of a vector, Gauss divergence theorem, Stoke's theorem. ***Electrostatics:*** Charges and forces, charge quantization, Coulomb's law, electric field, electric potential, application of Coulomb's law, potential and field due to one, two and three-dimensional charge distributions, electric dipole and quadrupole, Gauss's theorem and its applications, electrostatic energy, electrostatics in a dielectric medium, capacitors, parallel plate capacitor, cylindrical and spherical capacitors, capacitors in parallel and series circuit, moving charges, electric currents, current density, Ohm's law, Kirchhoff's law. ***Magneto-statics:*** Magnetic field, magnetic force, field and potential due to a magnetic dipole, torque on the dipole in an external magnetic field. ***Electrodynamics:*** Current carrying conductors, magnetic induction, Biot-Savart law, magnetic dipole moment, vector and scalar potential, Ampere's circuital law, induction and inductance, magnetic circuits, Faraday's law, Lenz's law, self and mutual induction, magnetic force between two circuits, alternating current, LCR circuits with DC and AC sources, dc motor, ac motor, dynamo, Helmholtz coil, Maxwell's equations

Essential Readings:

1. Fundamentals of Physics, Resnick, Halliday and Walker, 6th edition, Wiley
2. Fundamentals of Electricity and Magnetism, Arthur F. Kip, McGraw Hill

Supplementary Readings:

1. University Physics, Sears and Zemansky, 10th edition, Addison – Wesley series
2. Introduction to electrodynamics, D.J. Griffiths, 3rd edition, Prentice Hall
3. Electricity and magnetism, A.S. Mahajan and A. A. Rangwala, McGraw Hill

PH 301 WAVES AND OSCILLATIONS 4 Credits[3-1-0]

Oscillations: Equilibrium, concept of potential well, small oscillations, linear and transverse oscillations of a mass between two springs, diatomic molecule, damped oscillations, critical damping, Q of an oscillator, forced oscillator with one degree of freedom, transient and steady state oscillations, resonance energy, low and high frequency responses, two dimensional oscillator, normal modes, longitudinal and transverse oscillation of coupled masses, energy transfer between modes, coupled pendulum. ***Fourier analysis:*** Fourier series and Fourier coefficients, exponential representation for harmonic oscillations, expression for Fourier coefficients, non-periodic disturbance, Fourier integral, Fourier transform wave-train of finite length, constancy of $\Delta x \cdot \Delta k$ (uncertainty product), applications. ***Waves:*** Classical wave equation, wave velocity, boundary conditions and normal modes, dispersion relations, dispersive waves, acoustic and optical modes, Waves in continuous media, speed of transverse waves on a uniform string, speed of longitudinal waves in a fluid, energy density and energy transmission in waves, typical measurements, dispersion in waves, group and phase velocity, superposition of waves, linear homogeneous equations and the superposition principle, interference in space and energy distribution, beats and tones, Doppler effect. ***Ultrasonic:*** Production, detection and applications of ultrasonic waves. ***Electromagnetic Waves:*** Maxwell's equations, propagation of plane em wave in matter, energy flow and Poynting vector.

Essential Readings:

1. Vibrations and Waves by A. P. French.(CBS Pub. & Dist., 1987)
2. Waves: BERKELEY PHYSICS COURSE (SIE) by Franks Crawford (Tata McGrawHill, 2007).

Supplementary Readings:

1. The Physics of Waves and Oscillations by N.K. Bajaj (Tata McGraw-Hill, 1988)
2. Fundamentals of Waves & Oscillations By K. Uno Ingard (Cambridge University Press, 1988)
3. Schaum's Outline of Mechanical Vibrations by S. Graham Kelly (McGraw-Hill; 1st edition, 1996)

PH 302 PROPERTIES OF MATTER 4 Credits[3-1-0]

Elasticity: Stress and Strain, Hooke's Law, Young's modulus, Poisson's Ratio, work done in stretching and twisting a wire, twisting couple on a cylinder and wire, rigidity modulus by static torsion, torsional pendulum, rigidity modulus and moment of inertia, bending of beams, bending moment, uniform and non uniform bending, Koenig's method, Searle's method, determination of Young's modulus using microscope. ***Fluid dynamics:*** Stream line and turbulent flow, Bernoulli's theorem, Euler's equation, viscosity, Stoke's law, Poiseullie's equation, determination of coefficient of viscosity using - Stroke's method and Rankine's method, variation of viscosity of a liquid with temperature. ***Surface Tension:*** Surface energy, relation between surface tension and surface energy, equilibrium conditions at the interface between two liquids and at the liquid-solid interface, pressure under a curved surface, capillary effects, variation of surface tension with temperature, Jaegar's method. ***Low Pressure:*** Production and measurement of low pressure, molecular pump, rotary pump, diffusion pump, McLeod gauge, Bourdon spiral guage, Pirani guage, Ionization gauge, Knudsen gauge,

Essential Readings:

1. F. H. Newman and V. H. L. Searle, The general properties of matter (Edward Arnold, fifth ed., 1985).

2. Elements of properties of matter – D.S.Mathur (S.Chand & Co., 2001)

Supplementary Readings:

1. Fundamentals of Physics by D.Halliday, R. Resnick and J. Walker. (Wiley, 6th Edition, 2001)

PH 303 OPTICS 4 Credits[3-1-0]

Geometrical Optics: Introduction to geometrical and physical opticss, Fermat's principle of least action, reflection, refraction, refraction through spherical surfaces, conjugate foci for refraction at a spherical surface, transverse magnification of a spherically refracting surface, Lagrange and Helmholtz Laws of magnification, refraction through convex lens, deviation produced by a thin lens, cardinal points, lenses separated by a finite distance and equivalent focal length, graphical construction of images using cardinal points, aberration, optic centre of a lens, spherical aberrations, minimizing spherical aberration, chromatic aberration, condition for achromatism, coma, astigmatism, curvature of the field, Huygen's and Ramsden's eye pieces. ***Interference:*** Air wedge, determination of diameter of a thin wire by air wedge, test for optical flatness, Haidinger's fringes, multiple beam interference, Febry-perot interferometer and Febry-perot fringes, Jamin's & Rayleigh's interferometers, stationary waves in light, color photography, holography, temporal and spatial coherence, theory of partial coherence, coherence time and coherence length, purity of a spectral line, .***Diffraction***: Fresnel diffraction, Fresnel's assumption, explanation for rectilinear propagation of light, theory of zone plate, multiple foci of a zone plate, diffraction due to Circular aperture, opaque circular disc, straight edge, narrow wire, Rayleigh's criterion for resolution, resolving power of microscope, telescope, prism, grating. dispersive power of plane diffraction grating ***Fiber Optics:*** Propagation of light in fibers, numerical aperture, single mode and multi mode fibers, attenuation in optical fibers, spot size in fundamental mode, pulse dispersion in optical fibers, ray dispersion in step index fibers, parabolic- index fibers & material dispersion, applications of fiber optics;

Essential Readings:

1. Fundamentals of Optics by Jenkins A Francis and White E. Harvey, (Tata McGraw Hill Inc., 2011).
2. Optics by Ajoy Ghatak (Tata GcGraw Hill, 2008)

Supplementary Readings:

1. Optical Physics by S.G. Lipson, H. Lipson, and D.S. Tannhauser, (Cambridge University press,1995).
2. Fundamentals of Physics by D.Halliday, R. Resnick and J. Walker. (Wiley, 6th Edition, 2001)
3. Optics by N. Subramaniam & Brij Lal, (S. Chand & Co. Pvt. Ltd., New Delhi, 1990).

PH 304 INTRODUCTION TO MECHANICS 4 Credits[3-1-0]

Classical Mechanics: Dynamics of system of particles, center of mass, conservation of momentum, impulse, momentum of variable mass system, motion of rocket, **w**ork and energy theorem, conservative and non conservative forces, potential energy, energy diagram, stable and unstable equilibrium, gravitational potential energy, elastic potential energy, work done by non conservational forces, law of conservation of energy, elastic and inelastic collisions between particles, centre of mass and laboratory frames, rotational dynamics, angular momentum of a particle and system of particles, torque, conservation of angular momentum, rotation about a fixed axis, moment of inertia, parallel and perpendicular axis theorem, kinetic energy of rotation, motion involving both translation and rotation, law of gravitation, inertial and gravitational mass, potential and field due to spherical shell and solid sphere, motion of particle under central force field, two body problem and its reduction to one body problem and its solution, energy equation and energy diagram, Keppler's laws, orbits of artificial satellites. ***Quantum Mechanics:*** Inadequacies in Classical Physics, basic postulates, energy, momentum and Hamiltonian operators, wave function and its physical significance, probability density, Schrodinger equation, normalization, linearity and superposition of wave functions, Eigen values and Eigen functions, expectation Values, Schrodinger

equations for particle in a box and potential well. ***Statistical Mechanics:*** Limitations of classical mechanics, review of Statistical distributions (Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics) and their application, entropy and thermodynamic probability, microscopic and macroscopic states of a system, μ and Γ- space, ensembles (micro-canonical, canonical and grand canonical), Liouville's theorem, equal a priori probability.

Essential Reading:

1. An introduction to mechanics by D. Kleppner, Robert J. Kolenkow (Tata-McGraw Hill 2007)
2. Concept of Modern Physics by A. Beiser (Tata-McGraw Hill, 2005).

Supplementary Reading:

1. Fundamentals of Physic: Resnick, Halliday, & Wlaker, John Wiley & Sons Inc., 2004.
2. Fundamentals of Statistical and Thermal Physics by Frederick Reif (Tata McGraw-Hill, 2010)

PH 311 FUNDAMENTALS OF THERMAL & STATISTICAL PHYSICS 3 Credits [3-0-0]

Concept of thermodynamic state, extensive and intensive variables; heat and work, internal energy function and the first law of thermodynamics; ideal engine and Carnot cycle, concepts of entropy and temperature as conjugate pair of variables; second law of thermodynamics, entropy maximum and energy minimum principles. Entropy: multiplicity and disorder, Maxwell's demon ; Thermodynamic potentials; conditions of equilibrium, concepts of stability, Maxwell's equations, metastable and unstable equilibrium; components and phases, Gibbs-Duhem relations; first order phase transitions and Clausius-Clapeyron equation; critical phenomena, some chosen applications from magnetic, dielectric and superconducting; heat engines and black body radiation. Thermodynamics of irreversible processes: entropy production; Elementary kinetic theory of gases; transport phenomena; Introduction to statistical mechanics and distribution functions. occupation probability in M-B, B-E, F-D statistics, distribution functions, criteria for applicability of classical statistics, specific heat of classical gas, Fermi gas, Fermi energy, electronic contribution to specific heat of metals, energy bands in conductors, insulators and semiconductors, modifications at metal-metal contact, p-n junction, details of tunnel diode.

Essential Reading:

1. M. W. Zemansky, *Heat and Thermodynamics*, McGraw-Hill Ltd., 6th Edition, 1999.
2. R. Bowley and M. Sanchez, *Introductory Statistical Mechanics*, Oxford Press, 2007.

Supplementary Reading:

1. H. B. Callen, *Thermodynamics and Thermostatistics*, John Wiley & Sons 2nd Ed.
2. L. A. Girifalco, *Statistical Mechanics of Solids*, Oxford University press, 2000.
3. A. Bieser, *Perspective of Modern Physics / Concept of Modern Physics*, Tata McGraw-Hill, 2005.

Prerequisite:

PH 312 PHYSICS OF QUANTUM WORLD 3 Credits [3-0-0]

Historical background of quantum theory, wave function and its Born interpretation, relation with measurement of dynamical variables, double slits experiments with em wave and matter wave; Delta-function as definite position and plane wave as definite momentum wave function, wave-packet as superposition of delta-functions and of plane waves, uncertainty principle, Gaussian wave packets, applicability of classical physics on the basis of uncertainty product, observables and operator formulation, eigenvalue and eigenstates, Schrodinger equation for time evolution, stationary states, spread of free particle wave packets, time energy uncertainty, natural line width of spectral lines, probability currents and their relation with the flux in beams of particles; Square well potentials (finite & infinite) and their applications, double, well potentials and examples like ammonia inversion, delta function potentials and examples like electron sharing in covalent bonds; Kronig-Penney model of 1-d crystals. Linear harmonic oscillator, outline of getting stationary states,

molecular vibrations and spectroscopy. barrier tunneling, examples of alpha-decay, scanning tunneling microscope, principle of tunnel diode etc; Angular momentum operators, eigenvalues and eigenfunctions, spin angular momentum, hydrogen atom using coulomb interaction, structure of H-line due to L-S interaction (derivation not needed), J-J coupling, fine structure and hyperfine structure, space quantization; Quatum statistics and its applications to metals, semiconductors etc.

Essential Reading:

1. A. Bieser, *Concept of Modern Physics*, Tata-McGraw Hill, 2005.
2. D. J. Griffith, *Introduction to Quantum Mechanics*, Pearson Education, 2007.

Supplementary Reading:

1. R. P. Feynman, *Lectures on Physics, V*ol.III, Narosa Publishing, 2008.
2. C. Cohen-Tannoudji, *Quantum Mechanics*, John Wiley & Sons, 2005.
3. C. Kittel, *Introduction to Solid State Physics*, John Wiley & Sons 7th Ed., 2004.
4. R. Bowley & M. Sanchez, *Introductory Statistical Mechanics*, Oxford Press, 2007.

Prerequisite: First level Physics course

PH 321 PHYSICS OF SEMICONDUCTING MATERIALS 3 Credits [3-0-0]

Crystal structure, periodic lattice and reciprocal lattice, application of quantum mechanics to periodic potentials, Bloch's theorem, band energies and band gap. Properties of metals, Fermi surface and transport properties, density of states, metal surface states and work function, bulk semiconductors and semiconducting devices, effective mass theory of band energy, tight binding model; Novel materials: super lattices, quantum well, quantum DOT and quantum wires, superconductivity, high Tc superconductors and their applications, polymers and optical materials; Density functional theory and properties of bulk and small clusters of atoms, Carr- Perinello method of molecular dynamics.

Essential Reading:

1. C. Kittel, *Introduction to solid state physics*, John Wiley & Sons, 2004.
2. S. Dimitrijev, *Principles of Semiconductor Devices*, Oxford University, 2006.

Supplementary Reading:

1. J. Singh, *Semiconductor Devices: Basic principles*, Wiley India, 2008.
2. P.Y. Yu and M.Cardona, *Fundamentals of Semiconductors Physics & Material Properties*, Springer Verlag, 1999.
3. Y. D. Jiles, *Introduction to Magnetism and Magnetic Materials*, Chapmean and Hall. (2nd edition)
4. J.M. Haile, *Molecular Dynamics*, John Wiley & sons, 1997.

Prerequisite: First level Physics course

PH 331 WORLD OF LASERS 3 Credits [3-0-0]

Brief history of LASER; Wave nature of light, interaction of electromagnetic radiation with matter, coherence; Particle nature of light, quantum theory of atomic energy level; Radiative and non radiative transition; Radiation and thermal equilibrium; Stimulated absorption, Spontaneous and stimulated absorption; Population inversion, gain and gain saturation, Active medium, Optical amplification; Pumping mechanism, three and Four level pumping mechanism, Optical resonator, laser oscillation; Metastable state, Q-stitching and mode locking. ; Properties of Laser, monochromaticity, coherence, directionality, bright ness, short pulse duration; Different types of LASERS: gas LASER, solid State LASER, fiber optic LASER, pulsed LASER, excimer LASER ; Applications of LASERS, principle of holography, application in holography, LASER application in modern industries, material technology, in medical science, in science and technology, in optical communication

Essential Reading:

1. Willam T. Silfvast, *LASER Fundamentals*, Cambridge University Press, 2nd Ed, 2004.
2. Orazio Svelto and David C. Hanna, *Principles of LASERS,* Springer, 4th Ed, 1998.

Supplementary Reading:

1. John F. Ready, *Industrial Applications of LASERS*, Academic Press, 2nd Ed, 1997.
2. Markolf H. Niemz, *LASER –Tissue interaction: Fundamentals and Applications*, Springer, 3rd Ed, 2007.
3. Ronald W. Waynant, *LASERS in Medicine*, CRC Press, 2002
4. A.K. Ghatak and K. Thyagarajan, *LASERS: Theory and Applications*, Macmillan Publishers India, 2000
5. LASERS: Principles, *Types and Applications*, New Age Instruments, 2004.

PH 332 PHYSICS OF THE UNIVERSE 3 Credits [3-0-0]

Astronomy and physics, photometry, observational instruments, stellar spectra, stellar evolution, classification of stars, star clusters and binary stars, nucleo-synthesis and formation of elements, galaxies and observed universe. Evolution of galaxies and their origin, quasars and active galaxies; Theories of the universe: from Newtonian cosmology to modern cosmology: Big-Bang theory and early universe, the universe and the arrow of time, confrontation between theories and observations.

Essential Reading:

1. E. Harrison, *Cosmology*, Cambridge University Press. 2nd Ed., 2000.
2. J. Narliker, *Introduction to Cosmology*, Cambridge University Press. 3rd Ed., 2002.

Supplementary Reading:

1. J. Narlikar, *Structure of the Universe*, Prentice Hall (Indian Edition)
2. Bormer and Gerhard, *The early Universe*, Springer Verlag, Berlin, 2003.
3. *The early Universe and Observational Cosmology*, Lecture Notes in Physics (vol.646), Springer Verlag, 2007.

Prerequisite:

PH 341 TREATISE OF EINSTEIN WORK & BEYOND 3 Credits [3-0-0]

Photon: From quantum paradox to quantum reality.
The concept of photon & Einstein' photoelectric effect, EPR paradox Schrodinger's cat paradox, quantum well, quantum wire, quantum dot, Bell inequality, Quantum computation, quantum cryptography, Grover and Shor's Algorithm ; **Brownian motion**, From pollen grain's to protein chain. ; Theory of Brownian motion (random walk model) Einstein's theory of Brownian motion, Langevin's theory of Brownian motion. ; **Special theory of relativity**: From discreteness to continuity. ; Relativistic world, Space time and relativity, *Definition of simultaneity , Moving rigid body and moving clock, Visualizing proper time in special relativity* ,Salient features of Einstein's paper on special theory of relativity.

Essential Reading:

1. J.Stachel, *Einstein's Miraculous year: Five papers that changed the face of physics* , Princeton University press, 1998
2. Neilson & Choung - *Quantum computation and quantum information*

Supplementary Reading:

1. N.D Mermin – *space and time in special relativity*, McGraw-Hill New york, Second edn
2. WT Coffey, Yu P kalmykov *The Langevin equation second edition*, World scientific, 2004.
3. Special issues of Physics teacher Vol- 46, no- 2 On Photon.
4. Special issues of Physics teacher Vol- 47, no- 4 On Special theory of relativity.

5. Special issues of Physics teacher Vol- 48,

PH 351 SCIENCE OF NANO MATERIALS 3 Credits [3-0-0]

Introduction to nano science and nano technology, nano structure and it's manipulation, nano particles and nano materials, Applications of nano functional material in different fields of science and technology, Different experimental techniques for evaluation of nano ordered structures in materials(XRD,SAXS,TEM etc); Introduction to biological macromolecules and their characterization with special emphasis to Small Angle X-ray Scattering (SAXS) ; Introduction to synthesis of nano particles and their characterization, physics of nano particles and their composites.

Essential Reading:

1. G. L. Hornyak, H. F. Tibbals, J. Dutta, H. F. Tibbals, *Introduction to nanoscience*, Taylor and Francis Inc, 2008.
2. Z. L. Wang, Y. Liu, Z. Zhang, *Handbook of Nanophase and nano structured materials Vol-I Synthesis*, Klwer Academic Publications, 2002.

Supplementary Reading:

1. T. Pradeep, *Nano: The essentials: Understanding Nanoscience &Nanotechnology*, McGraw-Hill professional publishing (1st Edn).
2. T. Chakraborty, F. Peeters, U. Sivan, *Nano-physics & Bio-electronics: A new Odyssey*, Elsevier Publications, 2002.

PH 352 X-RAY TECHNIQUES FOR STRUCTURE EVALUATION 3 Credits [3-0-0]

Production, properties and applications of x-rays, x-ray absorption and its roll in stricture evaluation, x-ray detectors, real and reciprocal space, structure factor, form factor, X-ray diffraction (XRD) and its applications, x-ray scattering and its applications, introduction to small Angle X-ray Scattering (SAXS) and its advantage in structure evaluation; Introduction to X-ray spectroscopy, Moseley's law and its applications, x-ray fluorescence (XRF), energy dispersive x-ray (EDX), particle induced x-ray emission (PIXE) and their applications; Introduction to medical x-ray and x-ray techniques (radiography, radiotherapy, CT scanning etc.)

Essential Reading:

1. J. A. Nielson and D. McMorrow, *Elements of Modern X-ray physics*, John Wiley&sons, 2001.
2. G. V. Pavlinsky, *Fundamentals of x-ray physics*, Cambridge International sci Pub, 2008.

Supplementary Reading:

1. A. K. Singh, *Advanced X-ray Techniques in Research and Industry*, Capital Publishing Company, 2006.
2. N. Kasai, M. Kakudo, *X-ray diffraction by macromolecules*, Springer, 2005.

Prerequisites: fundamentals of modern physics

PH 401 MATHEMATICS METHODS IN PHYSICS 4 Credits [3-1-0]

Curvilinear coordinates systems, Vector algebra and vector analysis, Vector & function spaces, Hilbert spaces, expansion of state vector, operators in infinite vector space. Determinants & matrices, eigenvalues and eigenfunctions, Vector calculus, gradient, divergent and curl, Tensors and linear algebra; Polynomials, generalized functions, Dirac delta function, gamma function, Fourier series & transform, Legendre functions and Transformation; Function of complex variable and complex analysis; Elementary group theory

Essential Reading:

1. G. B. Arfken and H. J. Weber, *Mathematical methods for Physicists*, Elsevier Academic Press, 6th Ed., 2005.
2. M. L. Boas, *Mathematical Method in Physical Science*, John Willy & Sons, 3rd Ed., 2006.

Supplementary Reading:

1. J. Mathews and R. L. Walker, *Mathematical Methods of Physics*, Pearson Education, 2005.
2. S. D. Joglekar, *Mathematical Physics*, Universities Press, 2005.
3. R. V. Churchil and J. W. Brown, *Complex Variables &Applications*, 7th Ed., 2003.

Prerequisite: First level Mathematics course

PH 402 NUMERICAL TECHNIQUES IN PHYSICS 4 Credits [3-1-0]

Ordinary differential equations & partial differential equations, Green's functions, Calculus of variations. Solutions of differential equations by various numerical techniques: Numerical techniques: finite difference calculus, interpolation & extrapolation, solution of simultaneous linear equations & roots of equations, least square curve fitting, numerical integration, matrix eigenvalue problems; Probability: random variables, binomial distribution, Poisson distribution & Gauss/normal distribution. Monte Carlo simulation: random walk problem, random number generators, magnetization at a finite temperature, diffusion & percolation problems.

Essential Reading:

1. G. B. Arfken and H. J. Weber, *Mathematical methods for Physicists*, Elsevier Academic Press, 6th Ed., 2005.
2. J. Mathews and R. L. Walker, *Mathematical Methods of Physics*, Pearson Education, 2005.

Supplementary Reading:

1. S. D. Joglekar, *Mathematical Physics*, Universities Press, 2005.
2. R. V. Churchil and J. W. Brown, *Complex Variables &Applications*, 7th Ed., 2003.
3. M. L. Boas, *Mathematical Method in Physical Science*, John Willy & Sons, 3rd Ed., 2006.
4. S. C. Chapra, *Numerical Methods for Engineers*, Tata-McGraw-Hill. 5th Ed, 2007.

Prerequisite: PH 501: Mathematical Methods in Physics - I

PH 403 CLASSICAL MECHANICS 4 Credits [3-1-0]

Review of Newton's and conservation laws, system of particles, constraint, de-Alembert principle, generalized coordinates & Lagrangian equations, variational & Principle of least action and Hamilton principles and Lagrangian formalism, Hamilton equation of motions, Canonical transformations and Hamilton-Jacobi theory; The two-body central force problem, collisions and scattering by central force. The kinematics of rigid body motion and non-inertial frames, rigid body equation of motion; Liouvile's theorem, small oscillations, general wave motion, phase and group velocities, dispersion; Lagrangian and Hamiltonian formalisms for continuous systems and fields; Special theory of Relativity

Essential Reading:

1. H. Goldstein, *Classical Mechanics*, Addison Wesley, Pearson Education, 2007.
2. R. D. Gregory, *Classical Mechanics*, Cambridge University Press, 2006.

Supplementary Reading:

1. L. D. Landau and E. M. Lifshitz, *Course of Theoretical Physics- Mechanics*, (vol.-1), 3rd Ed., Pergamon Press.
2. R. P. Fynman, *Lectures on Physics (vol-1)*, Narosa Publishing, 2008.
3. D. Morin, *Introduction to Classical mechanics (with problems & solutions)*, Cambridge University Press, 2008.
4. T. W. B. Kibble and F. H. Berkshire, *Classical Mechanics*, 5th Ed., Imperial College Press, 2004.
5. N. C. Rana and P. S. Joag, *Classical Mechanics*, Tata-McGraw-Hill, 1991.

Prerequisite: Knowledge of Newtonian Mechanics & first level of mathematics course

PH 404 ELECTRODYNAMICS 4 Credits [3-1-0]

Potential formulation, Laplace & Poisson equations, Boundary value problems, method of images, multipole expansion, dielectrics and magnetic properties of materials; Time-varying fields, continuity equation, Maxwell's correction and equations, Poynting theorem, conservation of energy and momentum in of em fields, electromagnetic potentials, gauge invarience and transformations; Electromagnetic waves & its propagation in conducting and non-conducting media. Wave guides. Interference, diffraction and polarizations, coherence; Relativistic formulation of electrodynamics, co-variant form of Maxwell's equations, Gauge invariance and four potential, electromagnetic energy momentum tensor; Electrodynamics of a charged particle, radiation from a accelerated charge particle, retarded & Lienard-Weichert potentials, bremsstrahlung & synchrotron radiation, scattering by charged particles, applications to wave guides, fibres and plasmas.

Essential Reading:

1. D. J. Griffth, *Introduction to Electrodynamics*, Pearson Education. 3rd Ed., 2007.
2. D. Jackson, *Classical Electrodynamics*, Wiley and sons Ltd. 3rd Ed., 1998.

Supplementary Reading:

1. J. R. Reitz, F. J. Milford and R. W. Christy, *Foundation of Electromagnetic theory*, Addison Wesley Company / Narosa Publishing. 4th Ed., 2008.
2. A. Ghatak, *Optics,* Tata McGraw-Hill, 2004.
3. R. P. Feynman *Lectures on Physics (vol.II),* Addison Wesley, Narosa, 2008.

Prerequisite: 2nd level of electricity & magnetism course and 1st level of mathematics course

PH 405 STATISTICAL MECHANICS 4 Credits [3-1-0]

Review of thermodynamics - Laws of thermodynamics, entropy, thermodynamic potentials & Maxwell's relations, chemical potential & phase equilibria; Equilibrium statistical mechanics- phase space, micro-states, macrostates, micro-canonical, canonical & grand-canonical ensembles & and partition functions; Maxwell-Boltzmann, Fermi-Dirac & Bose-Einstein distributions, applications of statistical mechanics to ideal quantum gas, interacting systems, theories of phase transitions etc; Elementary concepts of non-equlibrium statistical mechanics.

Essential Reading:

1. H. B. Callen, *Thermodynamics & Thermostatistics*, John Wiley & Sons. 2nd Ed.
2. R. Bowley and M. Sanchez, *Introductory Statistical Mechanics*, Oxford Press, 2007.

Supplementary Readings:

1. M. W. Zemansky, *Heat & Thermodynamics*, McGraw-Hill, 1999.
2. L. Landau and E.M. Lifshitz: course in theoretical physics vol.5 (part-I) & vol.9 (part-II) - Statistical Mechanics, 3rd ed., Pergamon Press.
3. B. B.Laud, *Fundamentals of Statistical mechanics*, New Age Publication, 2007.
4. J. K. Bhattacharya, *Statistical Mechanics*, Allied Publishers Ltd., 1996.
5. L. E. Reichl, *A modern course in Statistical Physics*, Wiley & Sons, 2nd Ed., 1997.

Prerequisite: 1st level of thermodynamics course & elementary knowledge of Probability theory.

PH 406 CONDENSED MATTER PHYSICS 4 Credits [3-1-0]

Crystal systems & reciprocal lattice, Bragg's Law in reciprocal Lattice. Free & nearly free electron models & Fermi surface for metals, electron in periodic potential, Bloch's theorem and energy bands, tight binding model for band structure, density of states. Bondings in crystals, van-der walls, ionic, & covalent solids, electron in DC electric field; Transport properties - electrical & optical, effective mass, holes in semiconductors, laws of mass action, intrinsic & extrinsic semiconductors,

electron & holes mobilities, impurity level & p-n junctions; Lattice vibrations, phonons, adiabatic & harmonic approximations, lattice heat capacity, Einstein and Deby models, dielectric-polarization mechanism, Piezo, Pyro & ferro electricity; Magnetism: exchange interaction, dia-magnetism, para-magnetism, ferro-magnetism & anti-ferromagnetism, Hund's rule, Pauli magnetism, Heisenberg model, giant & colossal magneto-resistance, Hall effect; Superconductivity-basic phenomology, Meissner effect, Type-I & II super- conductors, BCS pairing mechanism.

Essential Reading:

1. C. Kittel, *Introduction to solid state physics*, John Wiley & sons, 8th Ed., 2004.
2. Ashcroft and Mermin, *Solid State Physics*, Thomson Learning, 2007.

Supplementary Reading:

1. J. Callaway, *Quantum Theory of Solid*, Academic Press, 2nd Ed.
2. D. Craik, *Magnetism Principles and Applications*, John Wiley, 2003.
3. F. Duan and J. Guojun, *Introduction to Condensed Matter Physics*, World Scientific, 2005.
4. L. Mihali and M. C. Martin, *Solid State Physics*, John Wiley & Sons, 1996.

Prerequisite: Basic quantum mechanics & electrodynamics

PH 407 QUANTUM MECHANICS - I 4 Credits [3-1-0]

Historical perspective and origin of quantum theory, wave mechanics, group waves and wave packets, uncertainty principle, motion and spread of wave packets. Schrodinger equation, application to one-dimensional problems, central potentials-hydrogen atom; Hilbert space formalism, state space and Dirac,s notation, mathematical formulation. Commutation relations and commutating observables. Creation and anhilation operators. Schrodinger, Heisenberg and interaction pictures, symmetries in quantum mechanics; General treatment of angular momentum, various commutations relations of angular mementum. Spin- Stern - Garlach experiment. Application of general theory to orbital and spin angular momentum. Identical particles, Pauli exclusion principle.

Essential Reading:

1. C. Cohen-Tannoudji, *Quantum Mechanics (vol.1),* John Willey & sons, 2005.
2. D. J. Griffith, *Introduction to Quantum Mechanics*, Pearson Education, 2007.

Supplementary Reading:

1. A. Bieser, *Perspective of Modern Physics / Concept of Modern Physics*, McGraw-Hill, 2005.
2. R. P. Feynman, *Lectures on Physics (vol.III),* Narosa Publishing, 2008.
3. L. Landau and E. M. Lifshitz, *Course in theoretical physics vol.3-Quantum Mechanics (non-relativistic),* 3rd Ed.
1. J. J. Sakurai, *Modern Quantum Mechanics*, Pearson Education, 2005.

Prerequisite: 2nd level mathematics and wave mechanics courses

PH 408 QUANTUM MECHANICS - II 4 Credits [3-1-0]

Addition of angular momenta. Clebs-Gordan coefficients; Approximate methods: WKB approximation, variational method. Bound state perturbation theory, application to fine structure, anharmonic oscillators and Zeeman Effect, time-dependent perturbation theory. Interaction with classical radiation fields; Scattering theory- Scattaring cross section, unbound states; EPR paradox & Bell's inequality, quantum teleportation, idea of quantum computation & informations.

Essential Reading:

1. C. Cohen-Tannoudji, *Quantum Mechanics (vol.2),* John Willey & sons, 2005.
2. D. J. Griffith, *Introduction to Quantum Mechanics*, Pearson Education, 2007.

Supplementary Readings:

1. R. P. Feynman *Lectures on Physics (vol.III)*, Narosa Publishing, 2008.
2. L. Landau & E. M. Lifshitz, *Course in theoretical physics vol.3-Quantum Mechanics (non-relativistic),* 3rd Ed.
3. J. J. Sakurai, *Modern Quantum Mechanics*, Pearson Education, 2005.
4. M. A. Nielsen and I. L. Chuang, *Quantum Computation & Quantum Information,* Cambridge University Press, 2002.

Prerequisite: PH 511: Quantum mechanics – I

PH 409 INTRODUCTION TO SPECTROSCOPY 4 Credits[3-1-0]

Atomic structure, Rutherford scattering, electron orbits, Bohr atom model, energy levels and atomic spectra, e/m of the electron, correspondence principle, nuclear motion, atomic excitation, Frank-Hertz experiment, spectra of hydrogen atom, quantum numbers, electron probability density, excitation and ionization of atoms, spectrum of singly ionized helium, spectrum of many electron atoms. vector atom model, orbital angular momentum, magnetic moment of an orbital electron, space quantization of an atom, radiative transitions, selection rules, Stark effect, normal Zeeman effect, Stern-Gerlach experiment, concept of spin, magnetic moment due to spin, Larmor's theorem, Larmor's precession, gyromagnetic ratio and Bohr Magneton, coupling schemes, selection rules, spin-orbit coupling, spectral notation, fine structure of spectral lines, D lines of sodium, anomalous Zeeman effect, Paschen-Back effect, discovery of deuterium, alkali and alkaline earth spectra. discovery of x-rays, continuous and characteristic x-rays and their spectra, x-ray diffraction – Bragg's law & Laue diffraction, Moseley's law, Moseley's law on the basis of Bohr's atom model.

Essential Reading:

1. Fundamentals of Molecular Spectroscopy by C. N. Banwell and E. M. McCash (Tata McGraw-Hill, 2007)
2. Introduction to Atomic Spectra, by H.E. White (Tata McGraw-Hill, 1984)

Supplementary Reading:

1. Concept of Modern Physics by A. Beiser (Tata-McGraw Hill, 2005).
2. Physics of Atoms and Molecule by B. H. Bransden, C. J. Joachain (Prentice Hall, 2003)
3. Physical Chemistry by P. Atkins, J. D. Paula, Atkins (Oxford University Press, Indian 8th Edition, 2008).

PH 422 THEORY & SIMULATION OF NANOSTRUCTURES 3 Credits [3-0-0]

Inter atomic Potentials: Potential energy surface, pair potential approximation, phenomenological potentials, Buckingham, Morse, Lenard-Jones and Berker potentials, Pseudo potentials, Many-body potentials; Molecular Dynamics: Models for MD calculations, initial value, isothermal equilibrium, boundaries, nano-design and nano-construction, solution of the equation of motion, Verlet, Gear-Predictor, and other methods, efficient force field computation, force derivation, list method, cell algorithm, scalable parallel method, Tight-binding MD, Carr-Perrinello MD; Characterization: Thermal stability, material properties, wear at nanometer level, mean values and correlation functions; Nano-engineering: Functional nanostructures, nano-machines, nano-clusters, influence of initial conditions, temperature, crystalline structure, etc. Simulated nano structure transformations.

Essential Reading:

1. M. A. Ratner and D. Ratner, *Nanotechnology: A Gentle Introduction to the next Big Idea,* Pearson, 2002.
2. J. M. Haile, *Molecular Dynamics*, John Wiley & sons, 1997.

Supplementary Reading:

1. M. Rieth, *Nano Engineering in Science and Technology: An Introduction to the world of Nano-Design,* World-Scientific, 2003.

2. C. Delerve and M. Lannoo, *Nanostructures-Theory & Modeling*, Springer Verlag, 2004.

Prerequisite: First level physics course

PH 431 NONLINEAR SYSTEM & CHAOS 3 Credits [3-0-0]

Dynamical systems with nonlinearity, phase portraits and flow in one, two and three dimensions, fixed point, limit cycle motions, bifurcation. Stability of fixed point, limit cycles; Deterministic chaos and strange attractors: Population growth, logistic maps etc., routes to chaos-period doubling, intermittancy, quasi periodicity. Concept of universality and renormalization, measure of Chaos-Poincare section, Lyapunov exponent; Idea of Fractal geometry and dimension: Euclidean and topological dimensions, Cantor set and Koch curves, Fractal boundaries, determination of fractal geometry, Hausdor exponent, Self affinity, Hurst exponent. Examples from physics, Engineering, biology and chemistry.

Essential Reading:

1. Paul. S. Addison, *Fractals and Chaos*, Overseas Press, 2005.
2. S. H. Strogatz, *Nonlinear dynamics & Chaos*, Levent Books (Kolkata) Indian Ed., 2007.

Supplementary Reading:

1. G. L. Baker and J. P. Gollub, *Chaotic dynamics-An Introduction*, Cambridge University Press, 1996.
2. F. Verhulst, *Nonlinear differential equations and dynamical systems,* Springer, 2nd Ed, 1999.
3. T. Kapitaniak, *Chaos for Engineers*, Springer, 1998.
4. D. W.Jordan and P. Smith, *Nonlinear Ordinary Differential Equations*, Oxford Univ. Press, 4th Ed., 2007.

Prerequisite: First level mathematics course

PH 462 VACUUM SCIENCE AND APPLICATION 3 Credits [3-0-0]

Vacuum and its necessity. Gas flow in vacuum systems, Pumping speed and through put; *Creation of Vacuum:* Rotary vane pump, Roots blower pump, Diffusion pump, Ionization pump, Diaphragm pump, Adsorption pump, Turbo molecular pump; *Measurement of Vacuum:* Pirani/Thermocouple gauge, Penning/Ionization Gauge (hot cathode and cold cathode), Capacitance gauge, Bourdon gauge, McLeod gauge; *Quality of vacuum:* Residual gas analyzer, Leak detection. Material selection and vacuum chamber; *Application of Vacuum in thin film deposition:* Thermal evaporation, DC and RF sputtering, Molecular beam epitaxy (MBE), Pulsed LASER deposition (PLD).

Essential Reading:

1. V. V. Rao, T. B. Ghosh and K. L. Chopra, *Vacuum Science and Technology*, Allied Publishers – 1998.
2. *N. Harris, Modern Vacuum Practice [Freely available on net] (*www.modernvacuumpractice.com/editor/user_DocView.asp?DocumentID=18*)*

Supplementary Reading:

1. D. M. Hoffman, B. Singh & J. H. Thomas, *Handbook of Vacuum Science and technology,* Academic press: 2005.
2. J. M. Lafferty, *Foundations of Vacuum science and Technology*, John Wiley and Sons, New York, 1998.
3. A. Chambers, R. K. Fitch & B. S. Halliday, *Basic Vacuum technology*, 2nd Ed, Overseas press, New Delhi -2005 or CRC press – 1998.

Prerequisite:

PH 507 NUCLEAR & PARTICLE PHYSICS 4 Credits [3-1-0]

Properties of Nuclei, nuclear two-body problem, nuclear force, binding energy and stability of nuclei. Nuclear models : Liquid drop and Shell models; Nuclear decay, nuclear kinematics & classification of nuclear reactions, fusion & fission reactions; Brief overview of ion-beam applications for materials (various types of detectors); Elementary particles and their properties, fundamental forces.

Essential Reading:

1. R. Eisberg and R. Resnick, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles,* Wiley India Pvt. Ltd., 2006.
2. Pehodgson, E. Gadioi , E. Gadioli-Erba, *Introductory Nuclear Physics*, Clarendon Press, 1997.

Supplementary Reading:

1. D. J. Griffith, *Introduction to Elementary particles*, John Wiley & sons. 2nd Ed., 2008.
2. D. H. Perkins, *Introduction to High Energy Physics*, 4th edition, Cambridge University Press, 2000.

Prerequisite: Quantum Mechanics courses

PH 508 ATOMIC & MOLECULAR PHYSICS 4 Credits [3-1-0]

Review of atomic structure of H, two electron systems, alkali system, Hartree-Fock method, density functional theory based Khon Sham equation, models for exchange co-relation functional, L-S coupling, JJ-coupling, fine structure & hyperfine structure. Zeeman, Stark & Paschen-Back effects. Auger & X-rays transitions; Molecular binding, LCAO, LCMO, molecular spectra (electronic, vibrational, rotational etc.); Principles of NMR, ESR, Raman spectra, LASERS.

Essential Reading:

1. R. Eisberg and R. Resnick, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles,* Wiley India Pvt. Ltd., 2006.
2. C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw-Hill Publishing Company limited, New Delhi, 2007.

Supplementary Reading:

1. B. H. Bransden, C. J. Joachain, *Physics of Atoms and Molecule*, Prentice Hall, 2003.
2. P. W. Atkin and R. S. Friedman, *Molecular Quantum Mechanics*, Oxford University Press, Indian Edition, 2004.
3. D. A. McQuarrier, *Quantum Chemistry*, Viva Books Private Limited, Indian Edition, 2007.
4. P. Atkins, J. D. Paula, *Atkins' Physical Chemistry*, Oxford University Press, (Indian Edition), 8th Edition, 2008.
5. H. E.White, *Introduction to Atomic Spectra*, McGraw-Hill.

Prerequisite: Quantum Mechanics courses

PH 511 ADVANCED QUANTUM MECHANICS 4 Credits [3-1-0]

Integral formulation of Quantum mechanics, Path Integral Integral, Relativistic wave equations, field quantization & particle processes, second quantization, interaction picture, S-matrix, many particle Green's functions and diagrametric methods, Feynman diagrams, many body physics, relativistic quantum mechanics of spin-1/2 particles, quantum theory of radiation, co-variant of perturbation theory, elements of quantum electrodynamics. Applications in condensed matter physics.

Essential Reading:

1. J. J. Sakurai, *Advanced Quantum Mechanics*, Pearson Education, 2007.
2. P. Strange, *Relativistic Quantum Mechanics: with Applications in Condensed Matter & Atomic Physics,* Cambridge University press, 1st Ed., 1998.

Supplementary Reading:

1. L. D. Landau and E. M. Lifshitz, *Quantum Electrodynamics (vol.4),* 3rd Ed. Pergamon Press.
2. S. Doniach and E. H. Sondheimer , *Green's Functions for Solid State Physicists*, Imperial College Press, 1998.
3. E. N. Economou, *Green's Functions in Quantum Physics*, Springer, 3rd Ed., 2006.

Prerequisite: Quantum mechanics courses.

PH 512	ADVANCED STATISTICAL MECHANICS	4 Credits [3-1-0]

Review of equilibrium statistical mechanics and its applications, theory of phase transition, critical phenomena, critical points and order parameter, thermodynamic properties and exponents, fluctuation of the order parameter, mean field theory .The renormalization group: the definition, fixed points and exponents, RG in selected models, perturbation expansion and dynamics. Ising Model and magnetism, correlation functions, superconductivity, superfluidity, Bose-Einstein condensation, fluctuation problems. Percolation problems; Kadona transformations, Ginzberg-Landau form. The correlation length and scaling hypothesis, scale transformation and dimensional analysis; Non-equilibrium statistical mechanics, ergodic hypothesis and basic postulates, Langevin equations, Focker-Planck equations, diffusion equation, entropy from trajectory of motion, instability of a trajectory

Essential Reading:

1. L. E. Reichl, *A modern course in Statistical Physics*, Wiley & Sons, 2nd Ed., 1997.
2. R. Zwanzig, *Nonequilibrium Statistical Mechanics*, Oxford University Press, 2001.

Supplementary Reading:

1. L. Landau and E. M. Lifshitz, *Course in theoretical physics vol.5 (part-I) & vol.9 (part-II) - Statistical Mechanics,* 3rd Ed., Pergamon Press.
2. R. Bowley and M. Sanchez, *Introductory Statistical Mechanics*, Oxford Press, 2007.
3. V. Balakrishnan, *Elements of Nonequilibrium Statistical Mechanics*, CRC Press, 2008.
4. D. S. Lemons, *An Introduction to Stochastic process in Physics*, John Hopkins Univ. Press, 2002.

Prerequisite: Statistical mechanics course

PH 513	DENSITY FUNCTIONAL THEORY & ITS RECENT APPLICATIONS	4 Credits [3-1-0]

Origin : Thomas-Fermi Theory, Electron Density, Potential Relation, Minimum Energy Principle and Chemical Potential, Exchange energy from Fermi hole, Hartree-Fock Method, Exchange energy in atoms, Correlations in Thomas Fermi Framework; Hohenberg-Kohn Theorem, v-Representability, derivative discontinuity, Spin Polarised systems, Density Matrix Functional, Basic Kohn-Sham equations, Variational principle and self consistent equations, Extension to magnetic and multi-component systems, approximations for exchange correlation energies, applications to atoms, molecules and solids; Relativistic and time dependent density functional theory and its application to excited states problems.

Essential Reading:

1. R. E. Nalewajski, *Density Functional Theory (Relativistic & Time Dependent),* Springer Verlag, 1996.
2. R. M. Dreizder and E. K. U. Gross, *Density Functional Theory*, Plenum Press, 1995.

Supplementary Reading:

1. M. Marques, C. A. Ullrich, C. A. F. Nogueira, A. Rubio, K. Burke, K. E. K. U. Gross, (Eds.) ,Springer, 2006.
2. R. M. Martin, *Electronic Structure: Basic Theory and Practical Methods*, Cambridge University Press, 2004.
3. J. Kohanoff, *Electronic Structure Calculations for Solids and Molecules: Theory and Computational Methods,* Cambridge University Press, 2006.
4. C. Fiolhais, F. Nogueira, M. Marques (eds.), *A Primer in Density Functional Theory*, Springer-Verlag, 2003.

Prerequisite: quantum mechanics and condensed matter physics courses.

PH 514 ADVANCED CONDENSED MATTER PHYSICS 4 Credits [3-1-0]

Second quantization, Fermi liquid, electron-electron interaction, electron-hole interaction in semiconductors, elementary excitation, electron-phonon interaction, polarons; Density functional theory and advanced band structure calculations, approximation in exchange potentials, molecular dynamics; Cooperative phenomena, paramgnetism, ferromagnetism, Ising model, superconductivity, BCS and Ginzberg-Landau theories, Bose-Einstein condensation, Dynamical mean field theory.

Essential Reading:

1. W. G. Aulbur, L. Jonsson, and J. W. Wilkins, *Quasiparticle Calculations in Solids, Solid State Physics Vol.54*, Academic Press, 2000
2. G. D. Mahan, *Many Particle Physics (Physics of Solids and Liquids)*, Springer, 3rd Ed., 2007.

Supplementary Reading:

1. F. Duan and J. Guojun, *Introduction to Condensed Matter Physics*, World Scientific, 2005.
2. R. M. Dreizder and E. K. U. Gros, *Density Functional Theory*, Plenum Press, 1995.
3. Avella, Adolfo; Mancini, Ferdinando (Eds.), *Lectures on the Physics of Strongly Correlated Systems X*I, (Eleventh Training Course in the Physics of Strongly Correlated Systems) Springer, 2006.
4. S. Doniach and E. H. Sondheimer , *Green's Functions for Solid State Physicists*, Imperial College Press, 1998.
5. H.Bruus and K. Flensberg, *Many-Body Quantum Theory in Condensed Matter Physics: An Introduction,* Oxford University Press, 2004.

Prerequisite: Condensed matter physics course

PH 522 PHYSICS OF SEMICONDUCTORS: FROM BULK QUANTUM DOTS 4 Credits [3-1-0]

Crystal structure of Bulk semiconductors, theories of band structure, effective mass theory, k-p method etc. Band gap tailoring, doping with tri- and penta-valent elements, electron and holes, Fermi- Dirac statistics and electron & holes charge concentrations. Computational Method of band structure calculation, preparation of bulk and low dimensional semiconductors; Transport properties: Transport phenomena in bulk semiconductors : quantum mechanical theories of the interaction of photon with matter and first principle techniques for the calculation of transport properties, applied electric field and drift velocity, carrier mobility and ohm's law, Diffusion and diffusion current equations , diffusion coefficient, Einstein relation, continuity equation, generation and recombination mechanism, minority carrier life time and diffusion length; Semiconductor heterostructures and their novel properties. Low dimensional semiconductors: two, one and zero dimensional semiconductors. Effect of quantum confinement. Semiconductor nono-structures and nano-tubes: the band structure and ground state properties. Dilute magnetic semiconductors: magnetic properties of doped semiconductors with magnetic impurities.

Essential Reading:

1. P. Y. Yu, and M. Cardona, *Fundamentals of Semiconductors Physics & Material Properties,* Springer Verlag, 1999.
2. J. Singh, *Semiconductor Devices: Basic principles*, Wiley India, 2008.

Supplementary Reading:

1. S. Dimitrijev, *Principles of Semiconductor Devices,* Oxford University, 2006.
2. C. Kittel, *Introduction to solid state physics*, John Wiley & Sons, 2004.
3. S. M. Sze, *Semiconductor Devices: Physics and Technology*, John Willey and Sons-2004.
4. Y. Fu and M. Wilander, *Physical Models of Semiconductor Quantum Devices*, Kluwar Academics, 1999.

Prerequisite: Quantum mechanics courses and basic knowledge of solid state physics

PH 523 SEMICONDUCTOR SPINTRONICS & QUANTUM COMPUTATION 4 Credits [3-1-0]

Properties of ferromagnetic semiconductor heterostructures, spin dependent scattering and tunneling, magneto-resistance, spin injection in ferromagnetic semiconductor heterostructures, spin injection and transport properties of micro- and nanoscale devices; Towards a semiconducting spin transistor, spin dynamics in semiconductors; coherent ensembles of spins, spin coherence in bulk and nanostructure semiconductors; Optical manipulation, transport and storage of spin coherence in semiconductors. Spin in quantum information processing. Electron spins in quantum; dots as Qubits for quantum information processing.

Essential Reading:

1. D. D. Awschaldm, *Semiconductor Spintronics & Quantum Computation*, Springer Verlag, 2002.
2. M. A. Nielsen and I. L. Chuang, *Quantum Computation & Quantum Information*, Cambridge University Press, 2002.

Supplementary Reading:

1. E. L. Nagaev, *Colossal Magneto-Resistance and phase separation in magnetic semiconductors,* World Scientific, 2002.
2. P. Kaye, R. Laflamme, M. Mosca, *An Introduction to Quantum Computing,* Oxford University press, 2007.
3. S. Bandyopadhyay and M. Cahay, *Introduction to Spintronics*, CRC Press, 2008.
4. S. Maekawa, *Concepts in Spin Electronics*, Oxford University Press, 2006.

Prerequisite: quantum mechanics & condensed matter physics courses

PH 524 COMPUTATIONAL CONDENSED MATTER PHYSICS 4 Credits [3-1-0]

Review of linear methods of band structure calculation. Density functional theory, Time dependent density functional theory, Pseudopotential, tight binding, KKR, augmented plane wave methods for band structurecalculations; Greens' function method-GW approximation coupled with density functional theory for first principle calculations. Calculation of transport properties. Application to bulk materials; Molecular Dynamics: Simulation of nano materials and their properties, tight binding and Carr-Perrinello molecular dynamics(Emphasis would be given to numerical calculations and development of computer codes.)

Essential Reading:

1. R. M. Martin, *Electronic Structure: Basic Theory and Practical Methods*, Cambridge University Press, 2004.
2. J. Kohanoff, *Electronic Structure Calculations for Solids and Molecules: Theory and Computational Methods,* Cambridge University Press, 2006.

Supplementary Reading:

1. R. M. Dreizder and E. K. U. Gros, *Density Functional Theory*, Plenum Press, 1995.
2. R. E. Nalewajski, *Density Functional Theory (Relativistic & Time Dependent),* Springer Verlag, 1996.
3. I. Turek, V. Drchal, J. Kudrnovsky, M. Sob, P. Weinberger, *Electronic Structure of disordered alloys, structure & interfaces,* Kluwar Academic Publishers, 1997.
4. V. V. Nemoshkalenko and V. N. Antonov, *Computational Methods in Solid State Physics,* CRC Press, 1998.
5. D. Hugues(ed), *Electronic Structure & Physical Properties of Solids (lecture notes*), Springer, 1998.

Prerequisite: Quantum mechanics & condensed matter physics courses.

PH 525 ELECTRONIC STRUCTURE OF DISORDERED ALLOYS 4 Credits [3-1-0]

Green's function method for solids, density of states using Green's function method. ; Method of configurational averaging. Virtual crystal approximation, coherent potential approximation, KKR-CPA equation. ; Augmented space formalism and its application to the study of averaged quatities of density of states and transport properties. Cluster coherent potential approxmation within augmented space formalism. ; Recursion method, Augmented space recursion for efficient calculation. First principle techniques for the study of disordered systems: bulk, surfaces and interfaces.

Essential Readings:

1. I.Turek, V.Drchal, J.Kudrnovsky, M.Sob, P.Weinberger, *Electronic Structure of disordered alloys, structure & interfaces*, Kluwar Academic Publishers. (1997)
2. A.Mookerjee, D.D.Sarma, *Electronic Structures of Alloys, Surfaces and Clusters,* Taylor & Francis (2003)

Supplementary Readings:

1. D.Hugues(ed), *Electronic Structure & Physical Properties of Solids (lecture notes)*, Springer (1998)
2. Wolfgang Pfeiler, *Alloy Physics*, Wiley VCH (2007)

PH 531 NON-LINEAR DYNAMICS, CHAOS & RECENT APPLICATIONS 4 Credits [3-1-0]

Introduction to non-linear dynamics, Chaos & Fractals. One Dimensional Flow: Fixed points and Stability, Bifurcations, flow on the circle. Two Dimensional Flow: Linear systems, Phase plane, Limit cycles, bifurcation in two dimensional systems. Chaos: Chaos on a strange attractor, Lorenz map, Periodic windows, Liapunov exponents, universality, Renormalization. Strange attractors: Henon map, Rossler system. Spatio-Temporal Chaos in extended system; Synchronization in nonlinear and chaotic systems. Fractals. (With examples from physics, chemistry, biology, fluid dynamics and electronic circuits.)

Essential Reading:

1. D. W. Jordan and P. Smith, *Nonlinear Ordinary Differential Equations,* Oxford Univ. Press, 4th Ed., 2007.
2. S. H. Strogatz, *Nonlinear dynamics & Chaos*, Levent Books (Kolkata) Indian Ed., 2007.

Supplementary Reading:

1. G. L. Baker and J. P. Gollub, *Chaotic dynamics-An Introduction*, Cambridge University Press, 1996.
2. F. Verhulst, *Nonlinear differential equations and dynamical systems,* Springer, 2nd Ed, 1999.
3. T. Kapitaniak, *Chaos for Engineers*, Springer, 1998.
4. P. S. Addison, *Fractals & Chaos,* Overseas Press, 2005.
5. D. Kaplan and L..Glass, *Understanding Nonlinear Dynamics,* Springer, 1998.

Prerequisite: Good knowledge of Partial differential equations and algebra

PH 532 PHYSICS OF MACROMOLECULES 4 Credits [3-1-0]

Variety of macromolecules, synthetic, natural and biopolymers, synthesis of macromolecules, molecular weight, concept of mono dispersity and poly dispersity, review of mathematical statistics, distribution of molecular weight, Review of thermodynamics for small molecules, thermodynamics of macromolecules, entropy of mixing, the Flory-Huggins lattice theory, enthalpy and free enthalpy of mixing, partial molar quantities, partial specific volume, chemical potential, static's and dynamics of dilute of polymer solution, Rouse model, Zimm model, Chain conformations and configurations, single ideal chain, mean square end to end distance, radius of gyration, freely joined chain, worm like chain, the random flight model, excluded volume, solvent quality, theta temperature, semi-dilute and concentrated polymer solutions, chain cross-over and chain entanglement; Experimental techniques: Macromolecular structure, principles of x-ray diffraction, x-ray diffraction by macromolecules. Viscosity, intrinsic viscosity, viscoelasticity. Osmotic pressure, determination of molecular weight by osmometer, second virial coefficient. Diffusion, Fick's first and second law, Einstein equation of diffusion. Light scattering, Rayleigh scattering, Fluctuation theory, determination of molecular weight, radius of gyration, second virial coefficient, diffusion coefficient and hydrodynamic radius of macromolecules; Some concepts of electrolytes and polyelectrolytes, Debye-Huckle theory, Donnan equilibrium, flexible plyelectrolytes, polypeptides, proteins, nucleic acid, self-assembly, colloids, surfactants, micelles. Scaling and universality.

Essential Reading:

1. S. F. Sun, *Physical Chemistry of Macromolecules,* John Wiley & Sons, 2004.
2. P. Munk and T. M. Aminabhavi, *Introduction to Macromolecular Science*, Wiley-Interscience, 2002.

Supplementary Reading:

1. G. Pattersom, *Physical Chemistry of Macromolecules*, CRC Press, 2007.
2. M. Doi and H. See, *Introduction to Polymer Physics*, Oxford University Press, 1996.
3. M. Doi, S. F. Edwards, *The Theory of Polymer Dynamics*, Clarendon Press, 1999.
4. A. E. Tonelli, *Polymers from Inside Out:In introduction to Macromolecules*, John Wiley-Interscience, 2001

Prerequisite: Basic Mathematics and statistics, basic thermodynamics.

PH 533 SYNCHRONIZATIONS AND ITS RECENT APPLICATION IN CHAOTIC SYSTEMS 4 Credits [3-1-0]

Synchronization in historical perspective. The basic notions: the self sustained oscillators and its phase, self sustained oscillators in nature, synchronization of a driven periodic oscillators, phase and frequency locking; Synchronization of higher order and Arnold tongues, synchronization of relaxor oscillators. Synchronization of two and many periodic oscillators, frequency locking, chains, lattices and oscillatory media; Synchronization in chaotic oscillators: Lorentz, Rossler, Marhieu oscillators; phase synchronization of chaotic oscillators, synchronization in the presence of noise, populations of globally coupled oscillators.

Essential Reading:

1. A. Pikovsky, M. Rosenblum and J. Kurths, *Synchronization: A Universal Concept in Nonlinear Science,* Cambridge University Press, 2002.
2. S. H. Strobatz, *SYNC: How Order Emerges From Chaos In the Universe, Nature, and Daily Life,* Hyperion, 2004.

Supplementary Reading:

1. G. V. Osipov, J. Kurths and C. Zhou, *Synchronization in Oscillatory Networks* (Springer Series in Synergetics), Springer, 2007.
2. S. H. Strogatz, *Nonlinear dynamics & Chaos*, Levent Books (Kolkata) Indian Ed., 2007.
3. Y. Kuramoto, *Chemical Oscillations, Waves, and Turbulence,* Dover Publications, 2003.
4. A. T. Winfree, *The Geometry of Biological Time*, Springer, 2001.

Prerequisite: Good knowledge of differential equations and linear algebra.

PH 535 LASER PHYSICS 4 Credits [3-1-0]

Brief history of LASER, wave nature of light, wave-particle duality, Electromagnetic radiation, interaction of light with matter, Black body radiation, General Physical principles behind amplification: Spontaneous emission. Stimulated absorption, Stimulated emission, Einstein coefficient and amplication, Line broadening, Ideas about line-width, Laser rate equations: The three level system, The four level system, Semi classical theory of LASER, active medium, population inversion, pumping mechanism, Role of feedback mechanism, Optical resonator, Modes of a rectangular cavity, Transverse and Longitudinal modes, The quality factor, Q- switching, Mode locking. CW operation, Pulsed operation.
Properties of LASER: Coherence, Directionality and Monochromacity

Different types of LASERS: Gas LASER, Solid state LASER, Liquid state LASER, Excimer LASER, Fiber optic LASER

Essential Readings:

1. William T. Silfvast, LASER Fundamentals, Cambridge University Press, 2nd Edition, 2004.
2. Anthony E. Siegman, LASERS, University Science Books, 1986.

Supplementary Readings:

1. A.K. Ghatak and K.Thyagarajan, LASERS: Theory and applications, Macmillan Publishers India, 2000.
2. K.R. Nambiar, LASERS: Principles, Types and Applications, New Age Instruments, 2004.
3. Orazio Svelto and David C. Hanna, Priniciples of LASERS, Springer, 4th Ed, 1998

PH 541 DIELECTRIC & MAGNETIC PROPERTIES OF MATERIALS 4 Credits [3-1-0]

Review of crystallography: - Symmetry, point groups, Miller indices, Laue's condition, Reciprocal lattice, Brillouin zones; **Magnetic Properties and magnetic materials**: - Van Vleck paramagneism Quantum theory of paramagnetism and Ferromagnetism. Temperature dependence spontaneous magnetization, magnetic domain, hystersis, Exchange interaction. Molecular field theory(Weiss law). Technological application of magnetic materials & multilayers in memory device, sensors, magnetic bubbles; **Phenomenological theories of magnetic order**- Interaction of atomic spins at large distance, molecular field theory, Spin waves, Ising model, Magnetic phase transition; **Di electric material :-** Classical & Quantum, theory of electronic polarisability and ionic polarisability spontaneous polarization , Hystersis, Frequency dependent polarization, Piezoelectricity; **An introduction to relaxor ferroelectricity**. Pervoskite crystal structure, Ferroelectric phases and domains , Curie Weiss behavior, Diffuse phase transition, Physics of Relaxor ferroelctricity , ABO3 relaxors, Application of ferroelectricity.

Essential Reading:

1. S. Blundell*, Magnetism in condensed matter*, Oxford university press, 2001.
2. A. Aharoni, *Introduction to the theory of ferromagnetism,* Oxford university press, 2001.

Supplementary Reading:

1. C. Kittel, *Introduction to solid state physics*, John Wiley & Sons, 2004.

2. Y. D. Jiles*, Introduction to magnetism and magnetic materials*, Chapmean and Hall. (2nd edition).
3. Ashcroft/ Mermin, *Solid state physics*, India edition IE, Thomsom books, Reprint, 2007.
4. L. L. Hench, J. K. West, *Principles of electronic ceramics*, John Wiley and sons,1995.

Prerequisite: 5th level condensed matter physics and quantum mechanics courses

PH 542 PHYSICAL & APPLICATION OF DIELECTRIC MATERIALS 3 Credits [3-0-0]

Maxwell Equations & Polarization, Macroscopic Electric Field, Local Electric Field at an Atom, Chemical Bond in Dielectrics, Structure of Dielectrics, Electrical Conduction in Dielectrics, Polarization Mechanisms in Dielectrics, Dielectric Relaxation, Ferro-electricity: Theory of Ferroelectrics, Domain, Imperfections & Polarization Reversals, Experimental Study of Thermodynamic Properties, Oxygen Octahedron, Order Disorder Ferroelectric, Critical Phenomena, Size Limit on Ferro-electricity, Applications of Ferroelectric Materials: Ferroelectric Ceramics Applications, Applications of Piezoelectric Ceramics, Ferroelectric Thin Films Applications, Electro-optic Applications.

Essential Reading:

1. A. J. Moulson and J. M. Herbert, *Electroceramics: Materials, Properties and Applications,* Wiley; 2nd Edition, 2003.
2. K. Uchino, *Ferroelectric Devices*, New York: Marcel Dekker, 2000.

Supplementary Reading:

1. M. E. Lines and A. M. Glass, *Principles and Applications of Ferroelectric and Related Materials,* Clarendon Press, Oxford, 2007.
2. Y. H. Xu, *Ferroelectric Materials and Their Applications*, Noth-Holland, 1991.
3. C. Kittel, *Introduction to Solid State Physics*, 8th Ed. John Wiley & Sons Pvt. Ltd, 2004.

Prerequisite: Basic knowledge of Electrostatics, Magnetostatics & Dielectric Materials

PH 543 BIO CERAMIC MATERIALS & APPLICATIONS 3 Credits [3-0-0]

Overview of structure and properties of materials: crystal structure, bonds in solid, crystal defect, surface property: surface tension & diffusion, and surface improvement, mechanical property, strengthening mechanism, thermal treatment and sterilization etc. ; Overview of bio implanting materials : synthetic polymers (polyethylene, polypropelyne), Acrylic polymer(PMMA),bio polymer(Collagens, elastin) metal alloys(steel, metal-chromium, platinum, titanium) , ceramics (Alumina, hydroxyapatite) , composite (fibers matrices) etc. Structure property relationship & mechanical properties of biological materials ; soft tissues and hard tissues. Orthopedic implants Materials: composition & mechanical strength of bone, Hydroxy Apatite ceramic for use in implantation, mechanical testing of ceramic materials for bone and joint replacement, Knee and hip joint replacement, Apatite morphology. ; Dental materials : Implant type, physical mechanical properties Dental materials, Biocompatibility of dental materials, Dental ceramics, zinc oxide and poly-Acrylic cements, methods of strengthening ceramics, Filling and metal – ceramic restoration, Dental ceramic for bonding , restoration application, chemical attack of dental ceramic. ; Analysis of human bone and teeth by PIXE, EDXRF, XRD, TGDTG and synthesis of Hydroxyapaptite by ion implantation

Essential Readings:

1. G.W. Hastings and D.F.Williams, *Mechanical properties of Biomaterials*, John Willey 1980
2. Sujata V.Bhat, *Bio- materials* second edition, Narosa , 2007

Supplementary Readings:

1. G.D. Winter, J.L.Leray, Klassde Groot, *Evaluation of Bio materials*, John Wiley, 1980.
2. Ph.d thesis of Tapas Ranjan Routray, *Characterisation & and Analysis of gallstone and hydroxyapaptite*, submitted to NIT, Rourkela

PH 544 POLYMER PHYSICS 4 Credits [3-1-0]

Polymer fundamentals: basic concept, nomenclature, classification of polymer, specific features of polymer, configurational states and chain conformations in polymer, ; Synthesis of Polymers: Polymerization and polycondensatation. ; Theory of polymer solution: Basic concept, Regular solution, Flory-Huggins theory, The solubility parameter concept, Equation of state theory, Polymer-polymer blend ; The rubber elastic state: Thermoelastic behavior and thermodynamics, The statistical mechanical theory of rubber, Swelling of rubbers in solvents. The glassy amorphous state, the molten state, Crystalline Polymer, Phase transitions of polymers, Crystallization, melting and glass transition, Theory of glass transition and Free volume, Liquid crystalline polymers, Polymer crystallization, ; Polymer characterization: Methods of investigation of polymer structure such as SAXS, WAXS, Thermal analysis, Microscopy, Vibrational Spectroscopy, Mechanical properties, ; Electrical properties of polymer: Dielectric properties and relaxation phenomena in polymer, Piezoelectric, and ferroelectric polymer. ; Polymer electrolyte: Fundamentals and classifications, Different generations of polymer electrolytes, Physics of polymer electrolyte, Thermodynamics, Structure and morphology, Ion transport mechanism in polymer electrolyte, Phenomenological concept and empirical relations, application of polymer electrolytes for electrochemical devices.

Essential Reading:

1. U. W Gedde; *Polymer Physics,* Chapman & Hall, New York, 1996 (Reprint).
2. D. I. Bower, *An Introduction to Polymer Physics*, Cambridge University Press, 1st Edition, (2005).

Supplementary Reading:

1. A. Tager, *Physical Chemistry of polymer*, Mir Publishers, Moscow, New Age International (P) Ltd. 2nd Edition (1978) Reprint.
2. M. Rubinstein and R. H. Colby, *Polymer Physics*; Oxford, New York: Oxford University Press, (2003).
3. F. M. Gray, *Solid Polymer Electrolytes*, VCH, New York (1991).

Prerequisite: Basic statistical mechanics and condensed matter physics

PH 551 CRYSTAL SYMMETRY & CRYSTAL PHYSICS 4 Credits [3-1-0]

The development of structure and types of matter: liquid, amorphous and crystalline states. Crystal structure: lattice, basis, unit cell. Concepts of crystal symmetry: point symmetry, translational symmetry, Bravais lattices, crystal systems, point groups, space groups Examples of structures such as NaCl, CsCl, the diamond structure, cubic perovskite structure. ; Fundamental principle of x-ray diffraction, Scattering of x-ray by electron and atoms, Structure factor and Intensity. Typical crystal structure determinations from x-ray powder diffraction data. Determination of crystallite size and strain from x-ray diffraction pattern. ; Crystal physics: Crystal symmetry and macroscopic physical properties, Symmetry of higher rank tensors and their applications to crystal properties: pyroelectricity, ferroelectricity, electrical conductivity, piezoelectricity, magnetic succiptibility and elasticity tensors.

Essential Reading:

1. J. F. Nye; *Physical properties of crystals: their representation by tensors and matrices*, Oxford Science Publication, Oxford University Press: New York, 2004 (Reprint).
2. H. P. Klug, L. E. Alexander, *X-ray diffraction procedures for crystalline and amorphous materials*, A Wiley Interscience Publication, 2nd Edition (1974). (both the above books are available in Library)

Supplementary Reading:

1. A. R. Verma and O. N. Srivastava, *Crystallography Applied to Solid State Physics*, New Age International (P) Ltd. 2nd Edition (2005) Reprint.
2. B. E. Warren, *X-ray diffraction*, Addison-Wesley Publishing Company, London, 1969.

3. C. Suryanarayana, M. Grant Norton, *X-ray diffraction: A practical approach*, Plenum Press, New York, 1998.

Prerequisite: Basic Mathematical Physics mainly matrix and tensor analysis.

PH 553 ADVANCED X- RAYS SRUCTURE ANALYSIS 4 Credits [3-1-0]

Introduction to x-rays, Introduction to X-ray diffractiontechniques, Qualitative and quantitative analysis of XRD data, prerequirements of Sample preparation for XRD data, Measurement of line intensities, Various factors effecting XRD intensities, Quantitative methods based on intensity ratios, The absorption diffraction method, Internal standard method, General RIR method, Normalized RIR method, Constrained XRD phase analysis, Detection limit issues Preliminary idea about XRF, PIXE, SAXS, GISAXS, EDX and their applications to characterize the materials with limitations of the techniques. X-ray spectroscopy and its application in characterization of materials. Advantages and disadvantages of the above mentioned techniques; Introduction to Medical application of X-rays and different equipments used for diagnosis purposes.

Essential Reading:

1. B. D. Culiety and S. R. Stock, *Elements of x-ray diffraction*,Pearson, 3rdEdn, 2001.
2. A. R. Verma, O. N. Srivastava, *Crystallography Applied to Solid State Physics*, New New Age International Publication, 2001.

Supplementary Reading:

1. A. K. Singh*, Advanced X-ray Techniques in Research and Industry*, Capital Publishing Company, 2006.

Prerequisites: Elementary knowledge on modern physics.

PH 554 PHYSICS OF THIN FILM TECHNOLOGY 4 Credits [3-1-0]

Physical vapor deposition (PVD):- Physical fundamentals and technical aspects Theories of film growth and applications, Sputtering(RF &DC), Pulse laser deposition and Molecular beam epitaxy; **Chemical vapor deposition (CVD):-** Physical fundamentals and technical aspects Theories of film growth and applications; Ferro Magnetic, dielectric and superconducting thin film and multilayers; **Langumuir Blodgett thin film:-** Technical details, Isotherm, Applications to organic electronics sensors etc Self assembly; **Sol-gel Spin coating:-** Technical details-hydrodynamics of spin coating (Newtonian and non-Newtonian behavior), dip coating; **Thin film characterizing technique:-** Surface Plasmon resonance spectroscopy , Ellipsometry, Atomic force Microscopy, and Tunneling electron microscopy, Transmission electronmicroscopy

Essential Reading:

1. Milton Ohring, *Material science of thin film deposition and structure*, academic press, John Wiley New york, 2006.
2. Maissel L I, Glang R *Hand book thin film technology* Mc Graw Hill 2 nd edition.

Supplementary Readi:

1. R. Sahu, *Physics of solid, nuclei and particle*, Narosa publishing house, 2006.
2. K. L. Chopra,*Thin film phenomena* , Mcgraw- Hill book company latest Edition.
3. C. C Julian, *Introduction of electron Scanning Tunneling Microscopy*, Coulombia university press, 2006

Prerequisite: condensed matter physics and quantum mechanics courses

PH 555	PHYSICS OF MATERIAL SYNTHESIS AND CHARACTERIZATION	4 Credits [3-0-0]

Bulk Materials Synthesis Techniques: Powders synthesis method; mechanical methods, hydrothermal synthesis of ceramic oxide powders, chemical methods, synthesis of nano-scale ceramic powders, powder characterization, particle size, shape, surface area, chemical composition, crystal structure and phase composition. **Thin Film Synthesis Techniques:** Physical vapor deposition, Chemical vapor deposition, Pulsed LASER Deposition, Sol-Gel, Molecular Beam Epitaxy, **Characterization Techniques:** X-Ray Diffraction Methods, X-Ray Fluorescence, Electron Dispersion Spectroscopy, Thermo gravimetric Analysis, Differential Thermal Analysis, Differential Scanning Calorimetery, Electron Microscopy-Transmission and Scanning Electron Microscopy, STM and AFM, Compositional analysis employing AES, ESCA and Electron Probe Microanalysis. Fourier Transform Infrared Spectroscopy.

Essential Reading:

1. M. Ohring, *The materials Science of Thin films*, Amazon, 2001.
2. M. N. Rahaman, *Ceramic Processing*, CRC Press, Taylor & Francis Group, FL, 2007.

Supplementary Reading:

1. D. A. Skoog, F. J. Holler and T. A. Nieman, *Principles of Instrumental Analysis*, 5th Ed., Hartcourt College Publishers, 1998.
2. *Lecture notes of AICTE Short term Winter School on Advanced Techniques for Characterization of Materials*, Feb. 12-23, 1996, IIT Delhi.
3. B. D. Culiety and S. R. Stock, *Elements of x-ray diffraction* ,Pearson, 3rdEdn, 2001.

Prerequisite: Basic knowledge of Quantum Mechanics

PH 556	X- RAY AND NANO- SCIENCE	4 Credits [3-1-0]

Production and properties of X-rays. Introduction to Nanoscience, Roll of X-ray in Nanoscience. Real and reciprocal space, application of reciprocal space to diffraction, Ewald's sphere, X-ray crystallography including space group and symmetries, scattering of X-ray by free and bound electrons, scattering by liquids; Introduction to Small Angle X-ray Scattering (SAXS), postulates of SAXS theory, Idea of different systems (ideal, non-ideal, monodisperse, polydisperse, dilute and dense systems). Overview of experimental SAXS system, Calculation of scattered intensity from a single particle & many particle systems, Refinement of SAXS data. Characterization of nano materials using SAXS data. General application of SAXS technique.

Essential Reading:

1. B. D. Culiety and S. R. Stock, *Elements of x-ray diffraction*, Pearson, 3rdEdn, 2001.
2. P. Linder, Z. Th. Neutron, *X-ray and Light: scattering methods applied to soft condensed matter,* Elsevier Science, 2002.

Supplementary Reading:

1. G. V. Paulinsky, *Fundamentals of x-rays*, Cambridge international science, 2008.
2. N. Kasai, M. Kakudo, *X-ray diffraction by Macromolecules*, Springer, 2005.
3. E. J. Mittemeijer, P. Scardi, Diffraction Analysis of microstructure of materials, Springer, 2003.

Prerequisites: Elementary knowledge on physics.

PH 561	PHYSICS OF MICROELECTRONIC AND PHOTONIC DEVICES	4 Credits [3-1-0]

The course introduces carrier transport in materials, physics of phenomena in semiconductors and optical fiber communications. This course provides basic idea to carry research in the area of semiconductors and photonics; Carrier Drift, Drift velocity, Carrier mobility, Carrier Diffusion,

Generation and Recombination Process, Diffusion and diffusion current equations, Diffusion coefficient, Einstein relation, Continuity equation, Thermionic Process, Tunneling Process, High Field Effects; Thermal equilibrium condition, Depletion region, Depletion capacitance, Current voltage characteristics, Junction breakdown, Heterojunction, junction potential; Behaviour of charged particles in conducting, insulating and semiconductor materials - thin film phenomena - Transport properties of thin films - Epitaxial growth - Microelectronics - Lithography and etch techniques - Microelectronic devices for Magnetic, dielectric, conductive and optical memory applications; Radiative Transition and optical absorption, Light emitting Diode, Semiconductor Laser, Laser Diodes, Optical Modulators, optical fibers, couplers, electro-optic devices, magneto-optic devices, Photo detector, Solar cell.

Essential Reading:

1. B. G. Streetman *and S. Banerjee , Solid State electronic devices,, 5th edition,* Prentice Hall of India *Private Limited, New Delhi, 2000.*
2. S. M. Sze, *Semiconductor Devises (Physics and Technology),* John Wiley & Sons Inc. 2nd Edition 2002

Supplementary Reading:

1. C. Kittel, *Introduction to solid state physics*, 7th Edition, Wiley Student Edition Reprint 2006.
2. Jean-pierre Colionge, C. A. Colinge, *Physics of SemiconductorDevices,* Klumer Acamedic Publication, 2002.
3. N. D. Gupta, *Amitav Das Gupta, Semiconductor Devices Modelling and Technology*, Prentice Hall of India,2004.
4. S. Dimitrijeo, *Principle of Semiconductor Devices,* Oxford University 2006.
5. Jia- Ming Liu, *Photonic Devices*, Published by Cambridge University Press, 2005.

Prerequisites: Knowledge in elementary solid state Physics and semiconductor properties**.**

PH 562 SUPERFLUIDITY AND SUPERCONDUCTIVITY 4 Credits [3-1-0]

Introduction to Superfluidity, 4He and 3He and their properties, Claussius-Clapeyron relation, Properties of solids at low temperature, Superdiamagnetism, Bose-Einstein Condensate, Supersolid, Superfluid film,gauge symmetry breaking, Thermodynamics of Superconductivity, ; Phenomenology of superconductivity, review of basic properties, thermodynamics of superconductors, Meissner effect, London equations, Cooper pairs, coherence length, Ginzburg-Landau theory, BCS theory, Josephson effect, SQUID, excitations and energy gap, magnetic properties of type-I and type-II superconductors, flux lattice, Quantum vortex ; Introduction to high-temperature superconductors, Inhomogeneities, Superconducting order parameter fluctuation. Experimental Techniques for Low-Temperature Measurements, Material Properties and Superconductor Critical-Current Testing.

Essential Reading:

1. C. Kittel, *Introduction to Solid State Physics*. John Wiley & Sons 7th edition (2004) Reprint 2006
2. D. R Tilley and J. Tilley , *Superfluidity and superconductivity*, 3rd ed-- New Delhi: Overseas Press, 2005

Supplementary Reading:

1. N.W. Ashcroft and N.D. Mermin ,*Solid State Physics*, Thomson India, Edition, 4th Indian Reprint 2007
2. M. Tinkham, *Introduction to Superconductivity*. 2nd Edition Dover, 2004 (2nd edition of the work first published by McGraw-Hill Book Co., New York, in 1975)
3. Hagen Kleinert, *Gauge Fields in Condensed Matter*, Vol-I SUPERFLOW AND VORTEX LINES,
4. G. Deutscher, *New Superconductors : From Granular to High Tc*, World Scientific, 2006
5. Jack Ekin, *Experimental Techniques*, Oxford Uni.Press,2006

Prerequisites: knowledge in elementary solid state Physics and Statistical Mechanics.

PH 563 PHYSICAL PHENOMENON AT LOW TEMPERATURE 4 Credits [3-1-0]

Introduction with brief history, Need for low temperature, Techniques of attaining low temperature and its measurements, Ultra low temperatures (dilution refrigerator, adiabatic demagnetization, nuclear demagnetization and their measurements). Experimental determination of physical properties at low temperature (Electrical conductivity, thermal conductivity, Specific heat capacity, magnetic properties, thermoelectric power, etc), Magnetic field in addition to low temperature, Effect of magnetic field on the physical properties, Sources of magnetic fields. Measurements involving high magnetic field (Electron spin resonance, Nuclear magnetic resonance, SQUID).

Essential Reading:

1. Frank Pobell*, Matter and Methods at Low Temperatures* (Springer, 2007)
2. G. K. White and Philip J. Meeson, *Experimental Techniques in Low Temperature Physics*, (Oxford, 2002)

Supplementary Reading:

1. T. H. K. Barron and G. K.white, *Heat Capacity and Thermal Expansion at Low Temperature* (Kluwer academic, 1999)
2. Jack W. Ekin, Experimental *Techniques for Low Temperature Measurements* : *Cryostat Design, Material and Superconductor Critical Current Testing* (Oxford university press, 2006)
3. D.R. Tilley& John Tilley, *Superfluidity and Superconductivity* (Institute of Physics, 2003)

Prerequisite: Elementary Condensed Matter Physics

PH 564 MAGNETISM – PRINCIPLES & APPLICATIONS 4 Credits[3-1-0]

Basic concepts: Introduction, sources of magnetic field, electromagnetics, magnetic materials. *Magnetic measurements:* neutron diffraction, magnetoresistance, Hall effect, dc magnetization, ac susceptibility, magnetic scanning microscopy. *Interactions in magnetic material:* Molecular field theory, direct and indirect exchange interaction, band theory, spin waves, RKKY interaction, Kondo effect. *Relaxation & resonance in magnetic materials:* Electron spin resonance, nuclear spin resonance, Mossbauer effect, De-Haas-Van Alphen effect, cyclotron resonance. *Application of magnetism:* Refrigeration, magnetoelectric, magnetoeleastic, magnetic sensors. *Magnetic nanostructures:* Thin films, multilayers and nanoparticles. Superparamagnetism.

Suggested Readings:

1. *Nicola A Spladin,* **Magnetic Materials**, Cambridge University Press.
2. *Stephen Blundell,* **Magnetism in Condensed Matter**, Oxford University Press
3. *Ralph Skomski,* **Simple Models of Magnetism**, Oxford University Press
4. *B.D.Cullity & C.D.Graham,* **Introduction to Magnetic Materials**, IEEE press
5. *K.H.J.Buschow & F.R.de. Boer,* **Physics of Magnetism and Magnetic Materials**, Kluwer, Academic Press
6. *A. Morrish,* **The Physical Principles of magnetism**, IEEE Press

PH-565 DEFECTS IN SOLIDS 4 Credits[3-1-0]

Defects in lattice: point defects, linear crystal defects, localization, ion implantation, radiation damage, surface defects, defect dynamics. *Defect in metals:* Alloys, intermetallic compounds, quantum interference and weak localization. *Defects in semiconductors:* Lightly and heavily doped semiconductors, Impurity levels, localization of electronic states, hopping conduction, magnetic semiconductors, quantum hall effect. *Defects in superconductors:* vortices and its pinning, pinning effect on critical current capacity, artificial and natural pinning centers in superconductors, magnetic and non-magnetic pinning centers. *Defect related studies:* Positron annihilation spectroscopy, Photoluminescence spectroscopy, Electrical transport.

Suggested Readings:

1. *A. Kelly, G.W.Groves & P.Kidd* **, Crystallography and Crystal Defects**, John Wiley & Sons

2. *J.P.Hirth & J Lothe,* **Theory of Dislocations**, John Wiley Sons
3. *B.I.Shklovskii & A.L.Efros,* **Electronic Properties of Doped Semiconductors**, Springer-Verlag
4. *M. Tinkham,* **Introduction to Superconductivity**, Dover Publications
5. *J.S.Dugdale,* **The Electrical Properties of Disordered Metals**, Cambridge University Press.
6. *D.K.Schroder,* **Semiconductor Material and Device Characterization**, Wiley-IEEE Press

DETAILED SYLLABI OF LABORATORY COURSES

PH170	Physics Laboratory	0-0-3	2
PH 271	Thermal Laboratory	0-0-3	2
PH 272	Electricity & Magnetism Laboratory	0-0-3	2
PH 371	Waves and Optics Laboratory	0-0-3	2
PH 372	Properties of Matter Laboratory	0-0-3	2
PH 471	General Physics Laboratory	0-0-3	2
PH 472	Solid State Physics Laboratory	0-0-3	2
PH 473	Spectroscopy Laboratory	0-0-3	2
PH 571	Instrumentation Laboratory	0-0-3	2
PH 572	Advanced Synthesis Laboratory	0-0-3	2
PH 573	Computational Physics Laboratory	0-0-3	2
PH 574	Advanced Characterization Laboratory	0-0-3	2

PH 170 PHYSICS LABORATORY 2 Credits[0-0-3]

Error & error analaysis, graph drawing, least square fitting

List of Experiments

1. Bar pendulum,
2. Lee's Disc,
3. Young's modulus,
4. Newton's rings,
5. Diffraction grating(spectrometer),
6. Optical rotation,
7. Carry Foster's bridge,
8. Band gap of semiconductor-Four probe method,
9. Visocty of water by Stoke's Method
10. Surface Tension by Capillary Rise
11. Diode Characterstics
12. Comparision of Magnetic Moments

Reference: 1. Laboratory Manual,

Prerequisite

PH 271 THERMAL LABORATORY 2 Credits[0-0-3]

1. Heating Efficiency of Electrical Kettle
2. Thermo electric effect (see beck effect)
3. Peltier Effect
4. Determination of Stefan's Constant
5. Conversion of Mechanical Energy in to heat energy
6. Thermal conductivity of a poor conductor (Lees method)
7. Thermal conductivity of a good conductor (Searles method)

8. Heat Capacity
9. Thermal Expansion of Solids
10. Gas laws: Boyles law
11. Gas laws: Charles law
12. Joule Thomson effect of Metal

Reference: 1. Laboratory Manual,

Prerequisite

PH 272 ELECTRICITY & MAGNETISM LABORATORY 2 Credits[0-0-3]

1. Resistance of Galvanometer by Kelvin's method
2. Resonance in LCR Circuit
3. Electromagnetic induction and Faraday's law
4. To Study capacitance of capacitor by coulomb meter
5. I-V relationship in RL series circuit
6. Magnetic Hysteresis
7. Mutual induction by deflection method
8. Field Characteristics of Helmholtz-coil
9. Rise & decay of current in inductive circuit
10. Determination of ballistic constant of a b.g.
11. Frequency of ac supply & capacitance using electrical vibrator
12. Mutual inductance by Carey Foster's method
13. L & C by Maxwell's bridge
14. Capacitance using Schering Bridge

Reference: 1. Laboratory Manual,
Prerequisite

PH 371 WAVES AND OPTICS LABORATORY 2 Credits[0-0-3]

1. NEWTON'S RINGS – Determination of refractive index of liquids
2. Michelson Interferometer
3. Fresnel Biprism,
4. Advanced Spectroscopy,
5. To determine the wavelength of light using Fabry-Perot Etalon.
6. Measurement of Refractive Index of Dielectric Material using BREWSTER ANGLE METHOD
7. Resolving limit of a telescope system
8. Use of diffraction grating and its resolving limit
9. Potential energy curves of a i-double system and oscillations in if for various amplitudes
10. Study of oscillations of a mass under different combinations of springs
11. Speed of waves on a stretched string
12. To verify the existence of different harmonics and measure their relative amplitudes in complex wave

Reference: 1. Laboratory Manual,
Prerequisite

PH 372 PROPERTIES OF MATTER LABORATORY 2 Credits[0-0-3]

1. Study of laws of parallel and perpendicular axes for moment of inertia
2. Study of a compound pendulum
3. Study of bending of a cantilever
4. Study of torsion of a wire (static and dynamic methods)
5. Vertical oscillations of a spring with mass

6. Fly wheel
7. Study of oscillations under a bifilar suspension
8. KUNDT'S TUBE – Determination of Velocity of Sound in Air
9. COUPLED OSCILLATOR – Measurement of Normal Mode Frequencies
10. SONOMETER – Resonance Modes of a Stretched String & Velocity of Wave Propagation
11. Determination of Coefficient of Viscosity by Poiseuilles Method
12. Determination of Rigidity Modulus by Static and Dynamic Methods.

Reference: 1. Laboratory Manual,

Prerequisite

PH 471 GENERAL PHYSICS LABORATORY 2 Credits[0-0-3]

List of Experiments:

1. To determine fundamental charge by Milliken's oil drop expt.,
2. To determine Plank's constant by Black body radiation,
3. Measurement of e/m,
4. Measurement of Hall coefficient,
5. To obtain B-H loop,
6. Measurement of different noise level using sound level meter,
7. Franck-Hertz Experiment,
8. Refractive Index of medium by Michelson interferometer,
9. Current balance,
10. Variation of magnetic field by Helmholtz coil

Reference: Laboratory Manual

Prerequisite : 1st level physics courses

PH 472 SOLID STATE PHYSICS LABORATORY 2 Credits[0-0-3]

List of Experiments:

1. Band gap of semiconductor crystal by four-probe arrangement,
2. Magneto resistance of a given sample,
3. Measurement of Dielectric constant & Curie temperature,
4. Dispersion relation of mono & diatomic lattice,
5. Tc & Jc of superconducting sample,
6. Young's modulus by Piezoelectric oscillator,
7. Mass susceptibility by Guoy balance,
8. Lande's g factor by ESR spectrometer in MHz range,
9. V vs I of semiconductor by varying temperature(low),
10. Refractive Index of transparent solid media at different temperature,
11. Study of Hysteresis loop of Ferroelectric/Ferromagnetic materials & estimate the energy.

Reference : Laboratory Manual

Prerequisite : 1st level physics courses

PH 473 SPECTROSCOPY LABORATORY 2 Credits[0-0-3]

List of Experiments:

1. Determination of wavelength of x-ray radiation from diffraction pattern of the given cubic crystal system,
2. Study of absorption lines of Na vapour,
3. Determination of wavelength of the given LASER source with the aid of grating,
4. Obtain and analyze the U-V spectra of an unknown system for different types of bonds,
5. Investigation of hyperfine structure of organic/inorganic/ionic radicals using EPR(ESR) spectrometer,
6. Optical microscopic studies of treated and untreated systems,
7. To obtain holographic image of a given object using LASER source
8. Diffraction of LASER by a narrow wire,
9. Wavelength of LASER source by Michelson interferometer,

10. To determine the resolution of gamma-ray spectrometer.

Reference: Laboratory Manual

Prerequisite : 1st level physics courses

PH 571 INSTRUMENTATION LABORATORY 2 Credits[0-0-3]

List of Experiments:

1. Microprocessor based Physics experiments
2. AD/DA converter circuits for interfacing
3. Creation of low temperature and its measurement
4. Measurement of Resistance of material at low temperature
5. Design of temperature sensor using commertial circuit resister and diods.
6. Design of power supply using IC
7. Design of power supply having + and –ve voltage supply to be used in OPAMP
8. Design and fabrication of a constant current source.
9. Demonstration of group wave using sound waves.

Reference : Laboratory Manual

PH 572 ADVANCED MATERIALS SYNTHESIS LABORATORY 2 Credits [0-0-3]

Synthesis of Nanomaterials, thin films, hydrogel, colloids, electroceramics etc. in research laboratories.

PH 573 COMPUTATIONAL PHYSICS LABORATORY 2 Credits [0-0-3]

Programming for numerical calculations using various numerical techniques- roots of a equation, matrix eigenvalue problems, solving differential equations, use of Monte-Carlo simulation for statistical problems, etc., with Fortran & C languages application of MATLAB & OCTAVE.

Essential Reading:

1. S. C. Chapra, *Numerical Methods for Engineers*, Tata-McGraw-Hill. 5th Ed., 2007.
2. V. Rajaraman, *Programming in Fortran 77*, PHI, 4th Ed., 2003.

Supplementary Reading:

1. S. Chandra, *Computer Applications in Physics*, Narosa Publications, 2003.
2. S. J. Chapman, *MATLAB Programming for Engineers*, Thomson Learning.

Prerequisite: Knowledge of C-programming

PH 574 ADVANCED CHARACTERISTICS TECHNIQUES LABORATORY 2 Credits [0-0-3]

Use of Characteristics techniques like XRD, SEM, Particle Size Analyzer, etc.

DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCES

MA (Development Studies)

DETAILED SYLLABI OF COURSES

Sub Code	Subject	L-T-P	Credit
CS 171	Computing Laboratory – I	0-0-3	2
HS 311	Communicative English	3-0-0	3
HS 312	Creative Writing	3-0-0	3
HS 317	Introduction to the Structure of Modern English	3-0-0	3
HS 321	Organizational Behaviour	3-0-0	3
HS 327	Cognitive Science	3-0-0	3
HS 328	Sports Psychology	3-0-0	3
HS 330	Introduction to Indian Society and Development	3-0-0	3
HS 331	Sociology: The Science of Praxis	3-0-0	3
HS 340	Special Course in Economics	3-0-0	3
HS 341	Managerial Economics	3-0-0	3
HS 350	Contemporary Dance	3-0-0	3
HS 410	Literary Foundations: Methods and Genres	3-0-0	3
HS 411	Ethical Leadership and Literature	3-0-0	3
HS 418	Language and Writing	3-0-0	3
HS 420	Human Resource Management	3-0-0	3
HS 428	Psychometrics	3-0-0	3
HS 431	Special Course in Sociology	3-0-0	3
HS 440	Financial Markets and Institutions	3-0-0	3
HS 441	Special Course in Economics	3-0-0	3
HS 448	Health Economics and Policy	3-0-0	3
HS 500	Research Methodology	3-1-0	4
HS 501	Advanced Research Methodology	3-1-0	4
HS 511	Technical and Business Communication	3-1-0	4
HS 512	Literary Foundations: Methods and Genres	3-1-0	4
HS 513	Post-Colonial Consciousness and Development	3-1-0	4
HS 514	Mapping the Other: Theories for Alterity	3-1-0	4
HS 515	History of Ideas: The Modern Period	3-1-0	4
HS 516	Introduction to Critical Theories	3-1-0	4
HS 522	Social Psychology and Its Application	3-1-0	4
HS 523	Educational Psychology	3-1-0	4
HS 524	Cognitive Development and Assessment	3-1-0	4
HS 525	Psychometrics: Theory and Applications	3-1-0	4
HS 526	Clinical Paradigms, Psychological Disorders and Therapeutic Interventions	3-1-0	4
HS 527	Corporate Social Responsibility	3-1-0	4
HS 531	Social Institutions and Development	3-1-0	4
HS 532	Planning and Policy: Issues in India	3-1-0	4
HS 533	Development: Social, Anthropological and Political Perspective	3-1-0	4
HS 534	Natural Resource Management and Sustainable Development	3-1-0	4
HS 535	Gender and Development	3-1-0	4
HS 536	Trends and Issues in Tribal Studies	3-1-0	4
HS 537	Development Issues in Orissa	3-1-0	4
HS 538	Urban Governance and Development	3-1-0	4

HS 541	Economics of Development	3-1-0	4
HS 542	Poverty, Inequality and Human Development	3-1-0	4
HS 543	Global Issues in Development	3-1-0	4
HS 544	Environment and Development	3-1-0	4
HS 545	Indian Financial System	3-1-0	4
HS 546	Population Dynamics and Development	3-1-0	4
HS 548	Demographic Transition and Health Policies in Developing World	3-1-0	4
HS 549	Public Economics	3-1-0	4
HS 550	Theory of Money, Output and Employment	3-1-0	4
HS 551	Special Topics in Development Studies – II		3/4
HS 552	Special Topics in Development Studies – III		3/4
HS 553	Special Topics in Development Studies – IV		3/4
HS 570	Advanced Language Laboratory	0-0-6	4
HS 572	Statistical Laboratory	0-0-3	2
HS 592	Research Project – II	0-0-9	6
HS 593	Seminar & Technical Writing – I	0-0-3	2
HS 594	Seminar & Technical Writing – II	0-0-3	2
HS 595	Short Term Industrial/Research Experience	0-0-3	2
HS 596	Comprehensive Viva -Voce	0-0-3	2

HS 311 COMMUNICATIVE ENGLISH 3 credits (3-0-0)

Communication: Aspects and Issues, Verbal and Non-verbal Communication, Creativity in Communication, the Johari Window. Interpersonal and Impersonal Communication, Communication in professional contexts, Formal & Informal Communication in Organizations; Essentials of grammar, tricky grammatical choices; Effective Pronunciation, Loan Words, Foreign Words, Word-Formation, Vocabulary Building Exercises, Varieties of English; Speech Styles, the Job Process, Focus of Job Interviews; Report Writing, Guidelines for Preparing a Good CV, Drafting a Job Application Letter, Comprehension Skill Testing, Paragraph Writing, The Structure of Modern English, Grammaticality and Acceptability, Effective Writing, Degrees of Writing and Accuracy.

Essential Reading:

1. Ivor Williams, English for Science and Engineering, Cengage Learning, First Indian Reprint 2007.
2. S. Stevenson and S. Whitmore, *Strategies for Engineering Communication*, John Wiley & Sons (Asia) Pvt. Ltd. 2002.

Suggested Reading*:*

1. Scot Ober, *Contemporary Business Communication,* Biztantra, 5th Edition, Indian Adaptation, 2004
2. S. Clark and G. Pointon, *Word for Word*, OUP, 2004
3. M. Nurnberg and M. Rosenblum, *All About Words: An Adult Approach to Vocabulary Building*, W.R. Goyal Publishers & Distributors, New Delhi,2000.

HS 312 CREATIVE WRITING 3 credits (3-0-0)

The course will take a two-fold method for general progression. In the first part, students will sample published material (classical to contemporary) and produce texts in the genres of historical short narratives and short fiction. Students will sample a variety of genres, viz, fables, stories, poetry, and will familiarize themselves with different techniques of writing. Then they will individually produce texts in each genre and will submit them for discussion. Finally, each student will submit a portfolio of revised material and a long essay assigned by the instructor.

This course will introduce students to workshop method of instruction; they will find an opportunity to produce written work which will be reviewed by their fellow-writers; they will find an opportunity to improve their writing. Apart from broadening the literary scope in students, the course will help students read a text with a critical eye and will cultivate an appreciation of beauty for language. The following may be treated as content:

Essential Reading:

1. Tools and Techniques of Creative Writing
2. Creativity, Thought, Expression of Ideas and Writing
3. Genres
4. Sampling Texts from a Variety of Genres
5. Creative Project for Submission

Suggested Reading:

1. Ernest Hemingway, *The Old Man and the Sea*.
2. Richard Bach. *Jonathan Livingston Seagull*.
3. George Orwell. *Animal Farm*.

HS 317	INTRODUCTION TO THE STRUCTURE OF MODERN ENGLISH	3 credits (3-0-0)

Human Languages: The Nature of Human Language; Misconceptions about Language.
Basic Language Science: Phoneme, Morpheme, Phonology, Morphology, Syntax and Semantics. The Notion of Correct English: Grammaticality and Individual/Cultural Variations. Language Usage: Correct Writing; Proofreading and Editing; Different Stages of Writing; Consistency in Writing; Good, Bad and Appealing Writing.
Writing for Specific Purposes: Audience and Target.

Essential Reading:

1. W.S. Allen, *Living English Speech*. London: Longmans. 1954.
2. W.S. Allen, *Living English Structure: A Practice Book for Foreign Students*. London: Longmans. 1959.

Online Resources:

1. Purdue "OWL." http://owl.english.purdue.edu/
2. *The Blue Book of Grammar and Punctuation*. http://www.grammarbook.com/
3. "Guide to Grammar and Writing." Capital Community College Foundation. http://grammar.ccc.commnet.edu/grammar/

HS 321	ORGANISATIONAL BEHAVIOUR	3 credits (3-0-0)

Foundations of human behaviour; Individual differences: Genetic and Environmental influence; Abilities, Skills and Intellectual competence: Biographical characteristics; Ability-Job fit; IQ and job success ; Personality characteristics; Assessment of personality, Predicting Career success; Attitude and job satisfaction; Perception and Decision making in individual and groups; Social perception and Attitudinal biases at work ; Motivation and work performance; motivational problems; Cultural differences, Environmental and Organizational change; Stress and Well being: Sources of Stress, Workplace Stress, Consequences: Preventive and curative Stress Management ; Emotion and Moods: Emotional labour and pay; Emotional Intelligence; EQ and job success ; Organizational Learning: Thinking, Problem solving and creativity; Psychometric Tests and assessment.

Essential Reading:

1. S. P. Robbins, *Organizational Behavior,* Prentice Hall, 9th edition, 2002.
2. D. L. Nelson and J. C. Quick, *Organizational Behavior: Foundations, Realities & Challenges*, South Western College Publishing: Thomson Learning. 3rd Ed, 2000.

Suggested Reading:

1. C. T. Morgan, R. A. King, J. R. Weisz and J. Schopler, *Introduction to Psychology* , McGraw-Hill, 7th Ed,1993
2. J. B Miner, *Organizational Behavior: Foundations, Theories, and Analyses*, Oxford University Press US, 2001.

HS 327 COGNITIVE SCIENCE 3 credits (3-0-0)

Objective: Cognitive science is an interdisciplinary field of study that investigates how humans and other animals come to understand and know the properties of their external environment and process them to behave in a particular way. Cognitive science includes but not limited to philosophy, neuroscience, psychology, artificial intelligence, and linguistics. The broad curriculum of cognitive science hovers around Foundations of Cognition, Language and Cognition, Computational Intelligence, Cognitive Psychology and Cognitive Neuroscience.

Contents: Overview of Cognitive Science: Introduction to Philosophy of Mind, Cognitive Psychology, Cognitive Neuroscience, Language and Thought, Learning and Memory, Theory of Mind, Mind and Culture.Mind-Body Problem and Behaviorism: Psychology before the Cognitive Revolution, Interdisciplinary Approach, Linguistics: Syntax and the generativity of Language**.** Information Processing, Classical View of Information Processing, Artificial Intelligence, Formal Systems: Finite State Machines-The Turing Machine.Neuroscience: Brain Anatomy, Brain Imaging with special reference to functional Magnetic Resonance Imaging (fMRI), Neuron Doctrine, Neurophysiology, Computational Cognitive Neuroscince, Cajal's Synaptic Plasticity Hypothesis. Working Memory and Executive Control: Prefrontal Cortex, Limited Capacity, Serial Position Curve, Double Dissociations, Modal Model, Baddeley's Working Memory Model, Central Executive, Stroop Effect, Wisconsin Card-sorting Task.

Essential Reading:

1. Baars, B.J. & Gage, N.M. (2010). *Cognition, Brain, and Consciousness: Introduction to Cognitive Neuroscience* (2nd Ed.). New York: Academic Press, ISBN 978-0-12-375070-9.
2. Kolb, B. &Whishaw, I. (2006). *An Introduction to Brain and Behavior* (2nd Ed.). New York: Worth Publishers. ISBN 0-7167-1187-7.

Suggested Reading:

1. Kolb, B. &Whishaw, I. (2008). *Fundamentals of Human Neuropsychology* (6th Ed.). New York: Worth Publishers. ISBN 0-7167-9586-8.
2. Anderson, J.R. (2007). *How can the human mind occur in the physical universe?* New York; Oxford University Press. ISBN 978-0-19-532425-9.

HS 328 SPORTS PSYCHOLOGY 3 credits (3-0-0)

UNIT-I Introduction:

1.1. Meaning of Sports Psychology: Its nature and scope.
1.2. Objectives of sport psychology: Professional, Recreational and Curative.
1.3. Methods of sport psychology: Introspection, observation and experimental.

UNIT-II Individual Differences:

2.1. Meaning of Individual Differences and its relevance in sports.
2.2. Types of individual differences: Physical individual differences, psychological individual differences and socio-cultural individual differences.
2.3. Factors contributing to individual differences: Heredity, Gender, Race, and Geographical location.

UNIT-III Play :

3.1. Meaning of Play and work. Difference between play and work. Relationship between play and work.
3.2. Some important characteristics of play.

3.3. Theories of play: Recreational, Surplus – energy and Cathartic theory.

UNIT -IV Motivation:

4.1. Meaning and significance of motivation in performance enhancement of sports persons.

4.2. Role of financial and non-financial motivators in sports.

4.3 Theories of Motivation: Maslow's need – hierarchy theory and Herzberg's motivation – hygiene theory.

UNIT-V Learning and Training:

5.1. Concept of Learning and its types: Cognitive, Affective and Conative.

5.2. Meaning and objectives of training.

5.3. Classifications of sports training programme: Basic training programme, Advance training programme, and high performance level training programme.

Essential Readings:

1. D. S. Butt, ***Psychology of sport: The behavior, personality and performance of athletes*****,** Van Nostrand Reinhold, New York, 2nd Ed., 1987.
2. M. L. Kamlesh, ***Psychology of Physical Education and Sports***, Metropolitan Book Co. Pvt. Ltd. New Delhi, 2nd Ed., 1983.

Further Readings:

1. K. John and S. Deirdre, ***Psychology in Sport***, Psychology Press, New Fetler Lane, London, 2nd Ed, 1994.
2. R. B. Alderman, ***Psychological Behaviour in Sports***, Thomson Learning Publication, 1974.
3. A. K. Uppal, ***Principle of Sports Training***, Friends Publication, New Delhi, India, 2001.
4. A. S. Zilli and N. K. Chadha, ***Research Methods for Sports Scientists,*** Oscar Publication, Delhi, India, 2001.

HS 330	INTRODUCTION TO INDIAN SOCIETY AND DEVELOPMENT	3 credits (3-0-0)

Institutions and Social Development: Culture, Community, Organization and Society.
Caste, Class and Power; Sanskritization and Westernization; Little. Tradition and Great Tradition. Kinship, Decent, Family, Marriage, Religion and its' Changing perspectives. Technology, Agrarian Social Structure and Rural Institutions. Diffusion of Innovations; Process of Innovation; Role of advocates and advocate assets; Novelty characteristics; acceptors and rejecters of innovations; Culture content of social change; Social cultural and psychological barriers to change. Development, Displacement and Disaster Management.Organizations and Development: CBOs, CSOs, MADA, PESA, and P.T.G,
Community Driven Development and Process of Implementation of Development Projects: PRA, Micro Plan, Social Audit and Social Analysis.

Essential Readings:

1. P.K. Kar, *Indian Society*, Kalyani Publisher, Cuttack. 2000
2. Yogendra Singh, *Modernization of Indian Tradition*, Rawat Publications, Jaipur. 1996.

HS 331	SOCIOLOGY: THE SCIENCE OF PRAXIS	3 credits (3-0-0)

Objective: The course will introduce students to sociology – the study of society – and how the concept of society itself emerges as an object of research and analysis. The first part of the course will cover the emergence of sociology as a scientific discipline linked to the French Revolution and the industrialization of England, the "dual revolutions" often thought of as heralding the beginning of modern society. The second part of the course will consider how social stratification became central to the study of society and in movements for social change. Finally, the course will look at how contemporary sociologists have analyzed issues such as consumer society, the information age, and globalization. ;**Contents:**Culture and Society in the Age of the Scientific Revolution; The Age of Enlightenment; Revolutions of the Eighteenth Century; Industrialization and Social Change; Capital,

Manifesto of the Communist Party; The Protestant Ethic and the Spirit of Capitalism; Social Stratification–Gender, Race and Caste; Information Age; Consumer Society.

Essential Readings:

1. Karl Marx and Frederick Engels, *Manifesto of the Communist Party*, Progress Publishers, Moscow, USSR. 1848.
2. Max Weber, *The Protestant Ethic and the Spirit of Capitalism*, Routledge, New York, 1930.
3. Dipankar Gupta, *Social Stratification*. Oxford University Press, New Delhi, 1993.
4. Anthony Giddens, *Sociology*, Polity Press, UK, 2006.

Supplementary Reading:

1. Manuel Castells, 1996, *The Rise of the Network Society, The Information Age: Economy, Society and Culture*, Vol. I. Blackwell, Oxford, 1996.
2. Jean Baudrillard, *The Consumer Society: Myths and Structures* (1970), Sage Publications, California, 1998.

HS 341 MANAGERIAL ECONOMICS 3 credits (3-0-0)

Introduction to Managerial Economics; Applications of Economics in Managerial Decisions; Basic Techniques in Managerial Economics: Opportunity Cost; Role of the Managerial Economists; The Theory of Consumer Behavior: The Meaning of Demand; Law of Demand; Demand Determinants; Elasticity of Demand; Measurement of Elasticity of Demand; Demand Forecasting; The Meaning of Utility and Marginal Utility Analysis; Law of Diminishing Marginal Utility; Indifference Curve Analysis; Consumer's Equilibrium; Production and Costs Analysis: Theory of production; Law of Variable Proportions; General Applicability of Law of Diminishing Returns; Theory of Short Run and Long Run Cost; Determinants of Costs; Cost Forecasting; Profit Analysis: Theories of Profit; Depreciation; Profit Maximization and Planning; Cost-Volume-Profit (CVP) Relations; Break Even Analysis; Market Structure and Price Determination: Various Forms of Market Structures; Price Determination under Different Market forms Like Perfect Competition, Monopoly, and Oligopoly; Business Decision Making Under Risk and Uncertainty: Insurable and Non-Insurable Risk.

Essential Reading:

1. D. Gopalakrishna, *A Study In Managerial Economics*, Himalaya Publishing House,2006
2. D. Salvatore, *Managerial Economics: Principles And Worldwide Applications,* Oxford University Press,2008

Supplementary Reading:

1. L. J Truett and D. B Truett,. *Managerial Economics,* John Wiley & Sons, 2004
2. G.Ghosh, *Managerial Economics*, Tata Mcgraw Hill, 2008.
3. V. l. Mote, S. Paul and G.S.Gupta, *Managerial Economics: Concepts and Cases,*, Tata Mcgraw Hill, 2004.
4. C. Thomas and S. C. Maurice, *Managerial Economics: Concepts and Applications* (Special Indian Edition), Tata Mcgraw Hill, 2005.

HS 410 LITERARY FOUNDATIONS: METHODS AND GENRES 3 credits (3-0-0)

The course aims to sensitize the students to the richness and beauty of English literature and to foster a deeper understanding of people's way of life as reflected through literature. Students will be exposed to a variety of periods and genres that will develop their critical thinking processes, the ability to analyze and reason carefully, the ability to organize and present materials coherently both in written and oral forms, and the ability to understand and manage other people - all practical skills that allow scope for improved professional communication. The four principal genres to be discussed are drama, fiction, verse novel and short stories.

Essential Reading:

1. W. Shakespeare, *Macbeth.* John Wiley & Sons; The Manga edition, 2008
2. H. Lee, *To Kill a Mockingbird*. Warner Books; 1st edition, 1988.

3. Vikram Seth, *The Golden Gate*. New Delhi: Penguin Books India (Pvt.) Ltd, 1986
4. Jhumpa Lahiri, *Interpreter of Maladies*. Delhi: Harper Collins India, 2000

Suggested Reading:

1. *J. L. Badaracco, Questions of Character: Illuminating the Heart of Leadership through Literature, Harvard Business School Press, 2006*
2. *A. Simmons, The Story Factor: Inspiration, Influence, and Persuasion through the Art of Storytelling , Basic Books: US.* 2002
3. *R. Lebow and R. Spitzer, Accountability: Freedom and Responsibility without Control , Berrett-Koehler Publishers Inc. 2002*.
4. *William Shakespeare's 'Macbeth' (Modern Critical Interpretations*) (Hardcover). Harold Bloom (editor), 1987.

HS 411 ETHICAL LEADERSHIP AND LITERATURE 3 credits (3-0-0)

Objective: This course looks towards literature – especially stories, plays, biography and historical accounts – to understand how ethical issues in leadership may be sensibly managed and understood. People in leadership positions face moral dilemmas throughout their careers. These may involve functional issues where the distinction between right and wrong is blurred, fluid and disputed.The aim of the course therefore is to enable students to understand the basics of moral leadership that they can apply in their professional and personal lives. Through close study of specific literary texts, supplemented with classroom debates, this course will encourage students to discuss and deliberate on the following:

- Different styles of leadership and qualities inherent in each style of leadership
- Identification of skills and characteristics that help create and foster ethical leadership

Course Contents:

1. Introduction to The Moral Leader: A Literature-Based Leadership Course **2**. Learning through Literature **3.**Moral Challenge, Themes and Learning Points **4.***Endurance: Shackleton's Incredible Voyage***5**.*Blessed Assurance***6.***Trifles***7.***The Sweet Hereafter***8**.*The Remains ofthe Day***9**.*A Man for All Seasons*.**10**. *The Prince***11.***The Secret Sharer***12**.*Truman and theBomb* **13**.*Katharine Graham: The Pentagon Papers and Watergate***14**. *American Ground*: *Unbuilding the World Trade Center*

Essential Reading:

1. Sucher, Sandra J. (2008). The Moral Leader: Challenges, Tools and Insights. New York: Routledge.

Suggested Reading:

1. Rhode, D. L. (2006). Moral Leadership: The Theory and Practice of Power, Judgment and Policy. California: JosseyBass
2. Maxwell, J. C. (2007). The 21 Irrefutable Laws of Leadership: Follow them and Peoplewill Follow You. (10th Ed.). Tennessee: Nelson.

HS 418 LANGUAGE AND WRITING 3 credits (3-0-0)

This course will make students aware of different kinds of writing activities and their importance in everyday life**.**While grammaticality and acceptability are key terms when we discuss any piece of writing**,** we also highlight what the incoming trends are and what role **'**style**'** plays in writing**.** This course will highlight the connection between language and writing and the central focus will be on different varieties of writing engineering students come across**.**This course will include all the topics generally included in the Advanced English Writing**,** namely**,**

i. Grammaticality and Acceptability
ii. Language**,** Linguistics and Writing
iii. Writing for Specific Purpose

In addition**,** this course will include**,** from the start**,**

- in-class writing and editing practice **(**10 sets roughly**)**
- with the help of samples from as many texts as possible **(**5 texts tentatively**)**
- as well as samples from other texts selected from a range of popular prose and writing **(**5 in all**).**
- By and large**,** in weekly meetings**,** one hour of course-work **(**lecture**)** will be followed by one hour of writing practice**.**
- Practice will include some work with the entire class as well as some group work and individual work**.**

Objectives:

- Students will have a sound knowledge of analysing a piece of writing in its parts and in its totality**.**
- They will be able to write **'**correct**'** English and will be able to edit any piece of writing for clarity and correctness**.**
- They will be able to distinguish among good**,** bad and not-so-good writing**.**

Essential Reading:

1. Allen**,** W.S.*Living English Structure: A Practice Book for Foreign Students***.** London**:** Longmans**.** 1959**.**
2. Burton**,** Roberts Noel**.***Analysing Sentences: An Introduction to English Syntax***,** Longman**:** London**.** 1986**.**
3. Quirk**,** Randolph**,** and Sidney Greenbaum**.***A University Grammar of English***.** Longman Group**:** Essex**.** 1993**.**
4. Shapiro**,** Michael J **(**ed**).***Language and Politics***.** Basil Blackwell**.** 1984**.**

Supplementary Reading:

1. **"**Guide to Good Grammar and Writing**."<**http**://**grammar**.**ccc**.**commnet**.**edu**/**grammar**/>**
2. **"**The Purdue Online Writing Lab**."** URL **<**http**://**owl**.**english**.**purdue**.**edu**/>**

HS 420	HUMAN RESOURCE MANAGEMENT	3 credits (3-0-0)

Management of Human Resources in Organizations; Managerial roles and challenges in changing times; Quality of Work life in India; Strategic Human Resource Management: Essentials, HR Planning, Attracting, Developing and maintaining a quality workforce, Career management, Performance Appraisal; Managing Organizational Change: Planned Change; Managing resistance to change ; Organizational Development (OD) Interventions: Shaping Organizational Culture; Organizational Distress and Organizational Stress Prevention; OD efforts in India ; Leadership as a management function: Influencing, Inspiring and Rewarding Effort at work; Job design in Indian Scenario ; Managing Workforce Diversity; Corporate Social Responsibility, Ethical Issues at work, Indian Scenario.

Essential Readings:

1. G. Dessler, *Human Resource Management*, Prentice Hall, 7th Ed, 2000.
2. S. P. Robbins and M. Coulter, *Management*, Prentice Hall, 9th Edition 2007.

Suggested Reading:

1. C. V. Memoria and S .V. Gankar, *Personnel Management: Text and Cases*, Himalaya Publishing House, 22nd Ed, 2002.
2. W. C. French & C. H. Bell, *Organisational Development*, Prentice Hall, 4th Ed, 1990.
3. S. P. Robbins, *Organizational Behavior: Concepts, Controversies and Applications*, Prentice Hall, 9th edition, 2001.

HS 428 PSYCHOMETRICS 3 credits (3-0-0)

Objective: The course aims at orientating students on designing and developing psychological tests, understanding psychological theories behind test construction and standardization.
Contents: The broad syllabus covers the concept, theories, measurement and interpretation of psychological attributes like intelligence, personality, attitude etc., reliability and validity, steps in test construction and standardization.

Essential Reading:

1. Anastasi A. & Urbina S. (2009). *Psychological Testing* (7th Ed.). PHI Learning.
2. Murphy, K.R., & Davidshofer, C.O. (2004).Psychological Testing: Principles and Applications (6th Ed.). Prentice Hall.

Suggested Reading:

1. Bacharach, V.R., Furr, R. M., Furr, M. (2007). *Psychometrics: An Introduction*. Sage Publication.

HS 440 FINANCIAL MARKETS AND INSTITUTIONS 3 credits (3-0-0)

Introduction of financial System- financial system and economy, Reforms in the financial system, Role of Indian financial system-structure of financial system, nature and role of financial system; Financial Markets - the place of financial markets in the economy-real assets and financial assets, money market, capital market, primary market, secondary market, government securities market, foreign exchange market, debt market, and derivative market; Development of Financial Institution and Instrument- new financial instrument, evolution of development bank, changing role of development financial institution, banking and non banking institution, Commercial banks, co-operative bank, mutual funds, insurance companies, and financial regulation; Regulatory and Promotional Institutions- RBI, SEBI, the purpose of regulation, levels of regulations; Non-Bank Financial Intermediaries and Statutory Financial Organization- Small saving, Provident funds, and pension funds; Foreign Capital Flows-Types of foreign capital; Uses and determinants of foreign capital, Foreign Direct Investment (FDI), Foreign Portfolio Investment.

Essential Reading:

1. L.M. Bhole, *Financial Institutions and Markets: Structure, Growth and Innovation*, Tata McGraw Hill Publishing Company Limited, New Delhi, 2009
2. Bharati. V. Pathak *Indian Financial System*, Pearson Education in South Asia Publishing Company, New Delhi, 2006,

Suggested Reading:

1. V.A Avadhani, *Financial Economics: Theory and Practice*, Himalaya Publishing House, Mumbai, 2000
2. P. Chandra, *Financial Management: Theory and Practice*, Tata McGraw Hill Publishing Company Limited, New Delhi, 2005
3. H.S. Houthakar, and P.J. Williamson, *The Economics of Financial Markets,* Oxford University Press, 2000
4. C. Hung, and Litzenberger, *Foundation of Financial Economics*, North Holland,1998
5. H.J. Johnson, *Financial Institutions and Markets*, Tata McGraw Hill Publishing Company Limited, NY,1993.

HS 448 HEALTH ECONOMICS AND POLICY 3 credits (3-0-0)

Economics and Health Economics; The Relevance of Economics in Health Care; Micro Economics Tools in Health Economics; A Simple Model of Demand, Supply and Price Determination, Elasticity of Demand, Applying Elasticity of Demand to Health Policy; The Economics of Consumer Choice; The Theory of Firm Behavior, Welfare Implication, Imperfect Competition; Economic Efficiency and Cost Effectiveness in Health Care; The Demand for Health, Measuring Health Status, Determinants of

Health Status, Medical Care as An Investment, Factor Influencing Demand for Medical care, Measuring Demand for Medical Care; The Changing World of Health Care Finance, Private Health Insurance, Social Health Insurance, Theory of Risk and Insurance, Health Insurance and Market Failure, Cost-Benefit Analysis; Methods for Calculating QALYs and DALYs; The Impact of Economic Evaluation on Decision Making in Health Care, Lessons for Public Health Policy.

Essential Reading:

1. D. Wonderling, R. Gruen and N. Black, *Introduction to Health Economics,* Maidenhead: Open University Press, 2005.
2. S. Folland, A. Goodman and M. Stano, *Economics of Health and Health Care,* Pearson/Prentice Hall.

Suggested Reading:

1. A.Clewer, and D.Perkins, *Economics for Health Care Management,* Prentice Hall, London, 1998.
2. C. Donaldson, and K.Gerard, *Economics of Health Care Financing*, Macmillan Press. 2nd Edition, 2005
3. S. Morris, *Health Economics for Nurses: An Introductory Guide*, Prentice Hall, 1998
4. C. Phillips, *Health Economics: An Introduction for Health Professionals*. Malden, Mass: Blackwell Publishers, 2005.

HS 500 RESEARCH METHODOLOGY 4 credits (3-1-0)

Objective: The paper aims at equipping students with methods and designs they can apply in systematic examination and measurement of socio-economic phenomena. ; **Contents:** Introduction to Social Science Research; Types of Research Designs and Methods; Qualitative Research; Case Study, Observation, Interview, Genealogy, Questionnaires and Schedules.

Essential Reading:

1. Gupta, S. C. and Kapoor, V. K., *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons, New Delhi.
2. Bruce E. Wampold and Difford J. Drew, *Theory and Application of Statistics*, McGraw-Hill International Editions.

Supplementary Reading:

1. Donald L. Haruett& James L. Mwrphy*, Introductory Statistics Analysis*, Addison-Wesley Publishing Compnay.
2. Goon, A. M., Gupta, M. K. and Dasgupta, B., *An Outline of Statistical Theory*, Vol. 1, The World Press Private Limited, Calcutta, 1985.

HS 501 ADVANCED RESEARCH METHODOLOGY 4 credits [3-1-0]

Objective: These papers will expose students to quantitative methods in social science research. Use of statistical methods and basic econometrics can help them in data analysis.
Contents: Multivariate Significance Tests;The Normal Probability Curve**:** Properties and Applications, Logic of Hypothesis Testing, Type I and Type II Errors, Power of Statistical Tests, Linear Correlation and Regression, Factors Influencing Correlation Coefficients,Multiple Correlation and Regression; Computer Applications, Content Analysis, Special Analysis, Factor Analysis, stakeholder analysis and social audit.

Essential Reading:

1. Cramer, Duncan, *Advanced quantitative data analysis. Maidenhead*: Open University Press, 2003.
2. Creswell, John W. *Research design: qualitative, quantitative, and mixed methods approach*. 3rd ed. Thousand Oaks: Sage, 2009.

3. Neuman, William Lawrence. *Basics of Social Research: qualitative and quantitative approaches*. 2nd ed. Boston: Pearson/Allyn and Bacon, 2007.

Supplementary Reading:

1. Dane, Francis C. *Research methods*. Pacific Grove: Brooks/Cole, 1990.
2. Devlin, Ann Sloan. *Research methods: Planning, Conducting and Presenting Research*. Belmont, Calif.: Thomson /Wadsworth, 2006.

HS 511 TECHNICAL AND BUSINESS COMMUNICATION 4 credits (3-1-0)

Objective: The course aims at exposing students to various aspects of organisational communication. ; **Contents:** Communication: Aspects and Issues, Verbal and Non-verbal Communication, Creativity in Communication, the Johari Window. Interpersonal and Impersonal Communication, Communication in Professional contexts, Formal & Informal Communication in Organisations; Essentials of Grammar, Tricky Grammatical Choices; Effective Pronunciation, Loan Words, Foreign Words, Word-Formation, Vocabulary Building Exercises. Varieties of English; Speech Styles, the Job Process, Focus of Job Interviews; Report Writing, Guidelines for Preparing a Good CV, Drafting a Job Application Letter, Comprehension Skill Testing, Paragraph Writing.

Essential Reading:

1. Ivor Williams, *English for Science and Engineering*, Cengage Learning, First Indian Reprint 2007.
2. S. Stevenson and S. Whitmore,*Strategies for Engineering Communication*, John Wiley & Sons (Asia) Pvt. Ltd. 2002

Supplementary Reading:

1. S. Clark and G. Pointon, *Word for Word*, OUP, 2004
2. M. Nurnberg and M. Rosenblum, *All About Words: An Adult Approach to Vocabulary Building*, W.R. Goyal Publishers & Distributors, New Delhi,2000
3. Straus, Jane, *The Blue Book of Grammar and Punctuation*. (Available online at http://www.grammarbook.com)
4. *Guide to Grammar and Writing,* Web Pages available at http://grammar.ccc.commnet.edu/grammar/ and "The Online Writing Lab at Purdue" (OWL) WebPages available at http://owl.english.purdue.edu/

HS 512 LITERARY FOUNDATIONS: METHODS AND GENRES 4 credits [3-1-0]

Objective: The course aims to sensitize students to the richness and beauty of English literature and to foster a deeper understanding of people's way of life as reflected through literature. Students will be exposed to a variety of periods and genres that will develop their critical thinking processes, the ability to analyse and reason carefully, the ability to organise and present materials coherently both in written and oral forms, and the ability to understand and manage other people-all practical skills that allow scope for improved professional communication. ; **Contents:** The four principal genres to be discussed are drama, fiction, verse novel and short stories.W. Shakespeare: *Macbeth;* H. Lee: *To Kill a Mocking bird;* Vikram Seth*: The Golden Gate;* Jhumpa Lahiri: *Interpreter of Maladies.*

Essential Reading:

1. W. Shakespeare, *Macbeth.*John Wiley & Sons; The Manga edition, 2008
2. H. Lee, *To Kill a Mockingbird*. Warner Books; 1st edition, 1988.
3. Vikram Seth, *The Golden Gate*. New Delhi: Penguin Books India (Pvt.) Ltd, 1986
4. Jhumpa Lahiri, *Interpreter of Maladies*. Delhi: Harper Collins India, 2000

Supplementary Reading:

1. J. L. Badaracco**,** *Questions of Character: Illuminating the Heart of Leadership through Literature,*Harvard Business School Press, 2006

2. A.Simmons**,** *The Story Factor: Inspiration, Influence, and Persuasion through the Art of Storytelling***,** Basic Books: US.2002
3. R. Lebow and R. Spitzer, *Accountability: Freedom and Responsibility without Control ,* Berrett-Koehler Publishers Inc. 2002
4. *William Shakespeare's 'Macbeth' (Modern Critical Interpretations*) (Hardcover). Harold Bloom (editor), 1987

HS 513 POST-COLONIAL CONSCIOUSNESS AND DEVELOPMENT 4 credits [3-1-0]

Objective: The course will offer students an understanding of the contemporary multicultural world that needs to have reconciliation between indigenous settlers and the migrants. Students will understand questions of racial and ethnic prejudices and will locate their role as individuals/institutions towards a collective goal of nation building. ; **Contents:** Navigation and Cultural/Racial Encounters; Impact of Colonization and Colonial Consciousness; Western mode of Education, National Consciousness, Freedom Struggle and Independence; Postcolonial Development and Nation Building; Writing back.

Essential Reading:

1. Ashcroft, William D., Gareth Griffith, and Helen Tiffin, eds. *The Post-Colonial Studies Reader*. London: Routledge, 1995.
2. Barthes, Roland. *Empire of Signs*. London: Jonathan Cape, 1970.
3. Fanon, Frantz. *Black Skin, White Masks*. New York: Grove P, 1967
4. Fanon, Frantz. *Studies in Dying Colonialism*. New York: Grove P, 1965.
5. Memmi, Albert. *The Colonizer and the Colonized*. New York: Orion Books, 1965.
6. Said, Edward. *Orientalism*. New York: Pantheon Books, 1978.

Supplementary Reading:

1. Barker, Francis, Peter Hulme, and Margaret Iversen, eds. *Europe and Its Others*. U of Essex P, 1985.
2. Barlow, Tani, ed. *Colonial Modernity*. Durham, NC: Duke UP, 1993.
3. Blunt, Allison, and Gillian Rose, eds. *Writing Women and Space: Colonial and Postcolonial Geographies*. New York: Guilford P, 1994.
4. Butler, Judith. Gender Trouble: *Feminism and the Subversion of Identity*. London: Routledge, 1990.
5. Fanon, Frantz. *The Wretched of the Earth*. New York: Grove P, 1961.
6. Ferro, Marc. *Colonization: A Global History*. London: Routledge, 1997.

HS 514 MAPPING THE OTHER: THEORIES FOR ALTERITY 4 credits [3-1-0]

Objective: The course will introduce students to critical/theoretical writings that concern the idea of the Self, the other and the Society and the way multiple identity categories are framed and categorised in a world where questions of 'legitimacy' are of concern. ; **Contents:** Multiculturalism, Postmodernism and the Debate of Plurality; Concept of Alterity and Identity, Centre and Periphery, Debate of Alternative Identities.

Essential Reading:

1. Nealon, Jeffrey. *Alterity Politics: Ethics and Performative Subjectivity*. Duke University Press: Durham, 1998.
2. Foucault, Michel. *The Order of Things*. London: Tavistock, 1970.
3. Corbey, Raymond & Joep Leerssen. *Alterity, Identity, Image: Selves and Others in Society and Scholarship*. Amsterdam & Atlanta: Rodopi, 1991.

Supplementary Reading:

1. Geertz, Clifford. *Interpretation of Cultures*. Basic Books: New York. 1973.
2. Agamben, Giorgio, Daniel Heller-Roazen (Translation). *Homo Sacer: Sovereign Power and Bare Life*. Stanford University Press. Stanford, June 1998.

3. Guha, Ranajit. *Dominance without Hegemony: History and Power in Colonial India*. Harvard: HUP. 1997.

HS 515 HISTORY OF IDEAS: THE MODERN PERIOD 3 Credits [3-1-0]

This introductory course will survey the most important intellectual themes of the modern period. The focus of the course will be on different concepts from Psychoanalysis, Marxism, Existentialism, Postcolonialism and Poststructuralism. From Freud's 'oedipal complex' to Nietzsche's 'death of God', there will be discussions on concepts such as 'modernism', 'empire', 'imperialism', 'nation' and 'development' as expressed in some of the major cultural texts of the modern period. Comparative elements from the Indian subcontinent will be brought in to our weekly discussions.

Objectives:

1. The course will introduce students to a few primary texts on the key socio-cultural concepts of the modern period.
2. Students will have a theoretical understanding of binary distinctions and concepts such as Orient and Occident, representation and appropriation, etc.
3. Students will be able to understand social conditionings from the perspective of theoretical development of the modern period.

Course Description and Content:

It is a professional course in Development Studies Programme and special emphasis will be given to development of multiple thoughts, viz., gender and feminist thought, development of ethnic consciousness and identity, encounter with the other, subalternity, significance of existential subjectivism versus scientific objectivism, and queer centralism. The major theoretical portions for discussion are categorised under the following broad periods: World War I: (Impact on faith and progress; special focus on Sigmund Freud) ; Inter-War Era: (Communist and Fascist ideas; Utopian ideals; special focus on Marx) ; Post-World War II Syndrome (Existentialism; special focus on Nietzsche)

Essential Reading:

1. Beauvoir, Simone de. "Introduction: Woman as Other" in *The Second Sex* (1989).
2. Foucault, Michel. "We Other Victorians" in *The History of Sexuality* (1990).
3. Freud, Sigmund. 'Selections' from *Totem and Taboo* (1913) and *Civilization and Its Discontents* (1930).
4. Jacques Derrida, "Difference" from *Margins of Philosophy* (1972).
5. Marx, Karl. 'Selection' on India and from *The Portable Karl Marx*. Ed. by E. Kamenka (1983).
6. Nietzsche, Friedrich. "An Attempt at Self-Criticism" from *The Birth of Tragedy* (1886).
7. Said. Edward W. "Introduction." *Orientalism* (1977).
8. Sartre, Jean Paul. *'Selections' from Being and Nothingness* (1943).
9. Spivak, Gayatri Chakravorty. "Can the Subaltern Speak?" in *Marxism and the Interpretation of Culture*. Eds. Cary Nelson and Lawrence Grossberg (1988).

Supplementary Reading:

1. Guha, Ranajit. *"On Some Aspects of the Historiography of Colonial India" in Subaltern Studies I*. 1999.
2. Millet, Kate. *Sexual Politics* (1968).
3. Pollock, Sheldon. "Is There an Indian Intellectual History? Introduction to 'Theory and Method in Indian Intellectual History" in *Journal of Indian Philosophy*. Volume 36, Numbers 5-6, 533-542.
4. Stromberg, Roland N. *European Intellectual History since 1789*, 6th Edition, 1994.

HS 516 INTRODUCTION TO CRITICAL THEORIES 3 Credits [3-1-0]

This course will introduce students to basic critical theories of the humanities and the social sciences. Students will be able to see the development of theories historically, sample original texts pertaining to different ancient and modern theories, and use them in the context of their area of research. From Plato's *Republic* to the introduction of *Liberal Humanism* to modern gender and queer theories, students will survey and understand basic components of theoretical research. The focus will be on the following theories and students are free to add other theories and theorists based on their area of research for seminar presentation:

Content:

Psychoanalytic Criticism
Postmodern Criticism
New Historicism
Cultural Studies
Postcolonial Criticism
Gender Studies and Queer Theory

Suggested Reading:

1. Aristotle, Selections. *The Poetics*.
2. Edward Said.*Orientalism*, 1978; *Culture and Imperialism*, 1994.
3. Hayden White. *Metahistory*, 1974.
4. HomiBhabha.*The Location of Culture*, 1994
5. Jacque Lacan,*The Ego in Freud's Theory and in the Technique of Psychoanalysis*, 1988; "The Agency of the Letter in the Unconscious or Reason since Freud" (from *Écrits: A Selection*, 1957)

Essential Reading

1. Michel Foucault, *The History of Sexuality, Volume I*, 1980.
2. Plato, Selections. *The Republic*.
3. Richter, David, ed. *The Critical Tradition*, 3rd ed. Boston: Bedford-St. Martin's, 2006.

HS 522 SOCIAL PSYCHOLOGY AND ITS APPLICATIONS 4 credits (3-1-0)

Objective: The course aims at making students aware of social issues ranging from individual to group and organizational concerns. ; **Contents:** Social Issues in Aggression, Mass Communication, Consumer Behaviour, Diversity, Environment, Health Care, Legal Issues; Activism for Social Change; Influencing Public Policy.

Essential Reading:

1. S. Oskamp and P. W. Schultz: *Applied social psychology*, 2nd ed, Upper Saddle River, NJ: Prentice Hall, 1998.

Supplementary Reading:

1. L.Brahnan and J.Feist: *Health Psychology: An Introduction to Behavior and Health*, 5th edition, Wadsworth Thomson 2004
2. R. Baron and D. Byrne *: Social Psychology,* 10th Ed, Pearson Education, 2004
3. F.M. Moghaddam: *Social Psychology: Exploring Universals Across Cultures*, New York, W.H. Freeman and Company, 1998

HS 523 EDUCATIONAL PSYCHOLOGY 4 credits [3-1-0]

Objective: The course aims to appraise students about the teaching and learning process to reflect upon the mental abilities and related issues involved in educational settings. ; **Contents:** Learner Differences and Learning Needs; Modifying Students' Behaviour; Principles of Behaviourism, Measuring Cognitive Ability; Motivation in Teaching and Learning; Teaching-Learning process; Standardised Testing , Assessment and Evaluation of Performance.

Essential Reading:

1. A. Woolfolk: *Educational Psychology*. 9th edition, Pearson Education, 2004

Supplementary Reading:

1. N.L. Gage and D.C. Berliner: *Educational Psychology* (6th Eds.), New York: Haughton Mifflin, 1998
2. Ormrod, *J.E: Educational Psychology*. N.J.: Prentice-Hall, 1998
3. G.R Lefrancois: *Psychology for Teaching*, USA: Wadsworth, 1999

HS 524 COGNITIVE DEVELOPMENT AND ASSESSMENT 4 credits [3-1-0]

Objective: Cognitive Development and Assessment aims at providing a primary level understanding of various developmental milestones achieved by the child, the methods to assess them, typical and atypical developments, delays in development and its implications for psychological development along with possible intervention and prevention strategies to deal with such issues. **Content:** Concept and Theories of Development, Infant Perceptual Development (Visual and Auditory), Understanding Objects and Space, Understanding Number, Categorical Development, Memory Development, Causal Knowledge, Theory of Mind (Perception, Intentionality, Thinking, Belief and Pretending), Assessment of IQ and other developmental milestones.

Essential Reading:

1. Flavell, J.H., Patricia, H. M. & Miller, S.A. (2001). *Cognitive Development* (4th Edn.). Prentice Hall.
2. Mcclelland, J.L., Siegler, R.S. (2001). Mechanisms of Cognitive Development: Behavioral and Neural Perspectives. Lawrence Erlbaum Associates

Suggested Reading:

1. Singer, D.G., Revenson, T. (1996). *A Piaget Primer: How A Child Thinks* (Revised Edition). Plume Books.

HS 525 PSYCHOMETRICS: THEORY AND APPLICATIONS 4 credits [3-1-0]

Objective: The course aims at orientating students on designing and developing psychological tests, understanding psychological theories behind test construction and standardization. **Content:** the concept, theories, measurement and interpretation of psychological attributes like intelligence, personality, attitude etc., reliability and validity, steps in test construction and standardization.

Essential Reading:

1. Anastasi A. & Urbina S. (2009). *Psychological Testing* (7th Ed.). Phi Learning.
2. Murphy, K.R., & Davidshofer, C.O. (2004).Psychological Testing: Principles and Applications (6th Ed.). Prentice Hall.

Suggested Reading:

1. Bacharach, V.R., Furr, R. M., Furr, M. (2007). *Psychometrics: An Introduction*. Sage Publication.

HS 526 CLINICAL PARADIGMS, PSYCHOLOGICAL DISORDERS AND THERAPEUTIC INTERVENTIONS 4 credits [3-1-0]

Objective: To provide students the preliminary ideas regarding psychological disorders and maladaptive behaviour as well as basic approaches to deal with them. ; **Contents:** Current Paradigms in Psychopathology and Therapy; Stress Coping and Maladaptive Behaviour; Anxiety, Personality and Mood Disorders; Juvenile Delinquency; Therapeutic Interventions and Outcomes**;** Rehabilitation Issues and Community Participation.

Essential Reading:

1. Geoffrey Kramer, Douglas Bernstein and Vicky Phares : *Introduction to Clinical Psychology*, 7th Edition, Pearson Education, 2009

Supplementary Reading:

1. J.O.P., Diaz, R.S., Murthy, and R. Lakshminarayana: *Disaster Mental Health in India*. Indian Red Cross Society: New Delhi, 2004
2. G.C. Davison and J.M Neale: *Abnormal Psychology*. New York: John Wiley & Sons. 2001
3. Sarason, I.G and B.R. Sarason : *Abnormal Psychology*, New Delhi: Pearson Education, 2002

HS 527 CORPORATE SOCIAL RESPONSIBILITY 4 credits (3-1-0)

Objective: The course will cover the key characteristics of Corporate Social Responsibility (CSR) in the context of present-day management. The course aims to apprise students regarding business decision-making which is informed by ethical values and respect for people communities and the environment. The course also aims to make students aware of creating a strategic plan that enables an organization to reach out to its internal and external stakeholders with consistent messages. ; **Content:** Responsible business: a myriad of terms and concepts; How does CSR fit into the overall corporate strategy and why has CSR become so important; Drivers and constraints of corporate responsibility; The emerging sustainable value creation concept; The stakeholder corporation vs. the shareholder corporation; The natural environment of the business: employees. customers, investors, communities, business partners, governments, etc. Ethical programmes as instruments to gain a competitive advantage as well as make a positive contribution to the well-being of society; Corporate Responsibility indicators, standards and reporting (SA 8000, AA 1000, GRI, Global Compact, ISO 26000 etc); How to draw up your CSR report: case study; Critical issues in corporate responsibility in India; Public Policy on CSR in India.

Essential Reading:

1. William B. Werther Jr. and David Chandler, *Strategic Corporate Social Responsibility: Stakeholders in a Global Environment,* Second Edition, Sage Publications, 2011
2. Sanjay K Agarwal, *Corporate Social Responsibility in India,* Sage Publications, 2008

Supplementary Reading:

1. Mark S. Schwartz, *Corporate Social Responsibility: An Ethical Approach,* Broadview Press, 2011
2. Paul Hohnen and Jason Potts, *Corporate Social Responsibility: An Implementation Guide for Business*, The International Institute for Sustainable Development, ISBN 978-1-895536-97-3, 2007
3. George Pohle and Jeff Hittner, *Attaining Sustainable Growth through Corporate Social Responsibility*, IBA Global Business Services, 2008

HS 531 SOCIAL INSTITUTIONS AND DEVELOPMENT 4 credits (3-1-0)

Objective: The course aims at introducing the nature of rural and social Institutions of Indian Society to the students. ; **Contents:** Institutions and Social Development: Culture, Community, Organisation and Society, Caste, Class and Power; Kinship and Descent; Family, Marriage, Religion and its Changing Perspectives; Agrarian Social Structure and Jajmani Relation; Technology and Rural Institutions.

Essential Reading:

1. Milton Singer& Bernard S. Cohn, *Structure and Change in Indian Society*, Rawat, Jaipur, 1996
2. D.N.Majumdar & T.N.Madan, *An Introduction to Social Anthropology*, Mayoor Paperbacks, 1994
3. Harry M. Johnson, *Sociology: A Systematic Introduction*, Allied Publishers Private Limited, New Delhi, 1986

Supplementary Reading:

1. Harry M. Johnson, *Sociology: A Systematic Introduction*, Allied Publishers Private Limited, New Delhi, 1986
2. David G. Mandelbaum, *Society in India*, Popular Prakashan, Bombay, 1984
3. J.L.Kachroo & Vijaya Kachroo, *Society in India*, Bookhive Publication, New Delhi, 1957

HS 532 PLANNING AND POLICY: ISSUES IN INDIA 4 credits [3-1-0]

Objective: This course aims at providing the theoretical background related to the various economic aspects of the study of technique of economic planning. ; **Contents:** Need for and Role of Planning and Futures of Planning in Capitalist, Socialist and mixed economies. Types of Planning, Basic Components of plan model, Decentralized and Centralized Planning; Requisites for and Strategic for planning; Balanced and Unbalanced growth; Key Sectors, Choice of Technique; Resource mobilization, Sectoral allocation of resources; Technique of Planning Models; Consistency Conditions and optimization; Static and Dynamic inter-industry models; Linear programming and econometric methods; Shadow prices and macro and micro planning level; Indian Planning Exercises.

Essential Reading:

1. Lange, Oskar, *Essays on Economic Planning*, Bombay, Asia Publishing House
2. Lewis, W, Arthur, *Development Planning*, New York, Harper and Row Publishers
3. Agrawal, A.N and KundanLal, "*Economic Planning*", Vikash Publishing House, New Delhi

Supplementary Reading:

1. Tadaro and Smith, *Economic Development*, Prentice Hall
2. Uma Kapila, *Indian Economy Since Independence*, ISBN: 81-7188-326-5
3. Myrdal, Gunnar, *Asian Drama:an inquiry into the Poverty of Nations*, New York: Twentieth Century Fund
4. Sen, A.K, *Choice of Technique*, Blackwell

HS 533 DEVELOPMENT: SOCIAL, ANTHROPOLOGICAL AND PSYCHOLOGICAL PERSPECTIVES 4 credits [3-1-0]

Objective: Developmental issues are closely tied to socio-economic and anthropological context. Motivational, attitudinal and behavioural aspects are also involved. The paper aims to provide interdisciplinary and comprehensive view of the concept of development. ; **Contents:** Defining Development; Role of Anthropology in Development Planning and Social Change; Diffusion of Innovations; Process of Innovation; Role of Advocates and Advocate assets; Novelty characteristics; Acceptors and Rejecters of innovations; Culture content of social change; Socio-cultural and Psychological Barriers to Change; Psychological approaches to Cultural Studies: Culture and Personality: Benedict and Mead; Basic Personality and the Concept of Institutions: Kardiner; Modal Personality: Cora Du Bois; Development of Morality and Gender Roles, Social Perception, Prejudice and Attribution errors.

Essential Reading:

1. C.K., Sigelman, and E.A. Rider*: Life-Span Human Development*, Thomson and Wardsworth Publishers, 4th Ed, 2003
2. Ram Ahuja, *Social Problems in India*, Rawat, Jaipur, 1992.
3. Satish Kedia & John Van Willigen, *Applied Anthropology: Domains of Application*, PRAEGER Publisher, Westport, Connecticut, London, 2005.
4. S C Dube, *Understanding Change: Anthropological and Sociological Perspectives*, Vikas Publishing House Pvt. Ltd, New Delhi, 1993.

Supplementary Reading:

1. T.S. Saraswathi and Baljit Kaur : *Human Development and Family Studies in India: an Agenda for Research and Policy*, Sage Publications,1993

2. Mahendra Dev, *Inclusive Growth in India: Agriculture, Poverty, and Human development*, Oxford, New Delhi, 2008.

HS 534 NATURAL RESOURCE MANAGEMENT AND SUSTAINABLE DEVELOPMENT 4 credits [3-1-0]

Objective: The aim of the course is to highlight the importance of measures towards sustainable development in the wake of depletion of natural resources and environmental concerns. ; **Contents:** Concepts on NRM, CPR, Livelihood, Culture and Sustainable Development; Cultural ecology and Ethno-ecology; Theoretical and Methodological Approaches in NRM; Climate Change, Natural Calamity and Social Adaptation; Indigenous Knowledge and Natural Resource Management; Depletion of Natural Resources and Livelihood; Policy and Natural Resource Management: Water, Forest and Land; Gender and Livelihood.

Essential Reading:

1. Kartar Singh, *Managing Common Pool Resources: Principles and Case Studies*, Oxford, New Delhi, 1994.
2. G.P. Mishra &B.K. Bajpai, *Community Participation in Natural Resource Management*, Rawat publication, Jaipur, 2001.
3. G. Palanithurai, M.A. Thirunavukkarasu & G. Uma, *Planning at Grassroots*: *Government's Participation in People's Plan*, Concept, New Delhi, 2008.
4. Sumi Krishna, *Livelihood and Gender*, Sage, New Delhi, 2004.

Supplementary Reading:

1. Ram Prasad Panda, *Eco-conservation and Tribal development*, Sonali Publication, New Delhi, 2005.
2. S.K Agarwal & P.S. Dubey*, Environmental Controversies*, APH Publishing Corporation, New Delhi, 2002.

HS 535 GENDER AND DEVELOPMENT 4 credits [3-1-0]

Objective: This course aims at providing students an insight to various dimensions of globalization, gender and development and linkages between them. ; **Contents:** Conceptual clarity on Globalization, Gender and Development; Linkage between Globalization, Gender and Development. Structural impact of Globalization, Gendered impact of Globalization; Globalization and its Consequences on Women; Feminization of poverty, Feminization of Labour, Feminization of Violence; Incorporation of Gender into Development Analysis and Practice; Indicators of Gender Inequality and the Status of Women; Gender and Development Policy and Practice.

Essential Reading:

1. Agnihotri, S.B.: *Sex ratio in Indian Population: A Fresh Exploration*.
2. Boserup E.*: Women's Role in Economic Development.*
3. Desai, N. and M.K. Raj. (Eds.): *Women and Society in India*.

Supplementary Reading:

1. *Government of India: Towards Equality — Report of the Committee on the Status of Women in India*, Department of Social Welfare, Ministry of Education and Social Welfare, New Delhi.
2. ILO: *Women's Participation in the Economic Activity of Asian Countries.*

HS 536 TRENDS AND ISSUES IN TRIBAL STUDIES 4 credits [3-1-0]

Objective: The course aims at enhancing the awareness of students regarding important trends and issues in Tribal Studies. ; **Contents:** Definition of Tribe, Cultural Continuity between Tribal and Non-tribal Populations in India; Scheduled Tribes in India: Distribution, Classification: Racial and Linguistic; Social, Political and Economic Organisations and Tribal way of Life. Tribal problems in India: Land Alienation and Indebtedness, Education, Health, Forest Degradation, Cultivation, Impact

of liberalization, Industrialization and Urbanization, Displacement and Rehabilitation; Tribal Administration and Constitutional Safe-guards for tribes in India; Tribes and Problems of National Integration; Tribal Movements in Post-Independent India.

Essential Reading:

1. L.P. Vidyarthi & B.K. Rai, *The Tribal Culture of India*, Concept, New Delhi, 1985.
2. R.C. Verma, *Indian Tribes through Ages, Ministry of Information and Broad Casting*, Govt. of India, New Delhi, 1995.
3. Nadeem Hasnain, *Tribal India*, Palaka Prakashan, Delhi, 1992.

Supplementary Reading:

1. Apoorva Pandit& Ms. Sunanda Bhagwat, *Tribal Culture and Technology*, Inter India Publication, New Delhi, 2006.
2. Devendra Thakur & D.N. Thakur, *Tribal Development and Planning*, Deep & Deep Publication, New Delhi, 1997.
3. Pariyaram M. Chacko & K.S. Singh, *Tribal Community and Social Change*, Sage, New Delhi, 2005.

HS 537 DEVELOPMENT ISSUES IN ORISSA 4 Credits (3-1-0)

Objective: This course will provide a clear picture about the various issues in Orissa such are development policies, its economy, culture, health status, natural resources. It will help students to have a better understanding about the development scenario of a state and its vision in development. **Content:** State of Maternal and Child Health in Orissa, Trends in infant and Child Mortality, Causes of Infant and Child Mortality, Causes of Malaria, Demand and Access factor for Health Care Services, Health Infrastructure, Health expenditure, regional inequality in maternal and child health in Orissa, Interrelationship between socio-economic inequality and health status, Programmatic improvement achieved under the umbrella cover of NRHM, ICDS, and various state and national health programs. A Macro Economy Glance of Orissa's Economy including Income, Employment, Consumption expenditure and cost of living**,** Agriculture and Allied Sectors-the industrial sector, service sector, Infrastructure, poverty, social sector and public finance, Federal Finance-centre and state relationship, Culture and festivals, Displacement issues, Government policies on natural resource management, disaster mitigation, mining, forest and water resources.

Essential Readings:

1. Mishra, P.K. (ed). 1997. *Comprehensive History and Culture of Orissa*, Vol.2, Part 2, New Delhi: Kaveri Books.
2. Das, K. 1991. *Folklore of Orissa*, Bhubaneswar: Orissa Sahitya Academy.
3. Das, K and L. K. Mahapatra. 1993. *Folklore of Orissa*, New Delhi: National Book Trust of India.
4. Directorate of Economics and Statistics, Government of Orissa. 2005–06 to 2008–09. Economic Survey. Planning and Coordination Department, Government of Orissa.
5. Finance Department, Government of Orissa. 1996–2008. Demand for Grants of Health and Family Welfare Housing and Urban Development, Rural Development, Labour and Employment and Women and Child Development Departments. Government of Orissa.
6. Health and Family Welfare Department. 2002. Orissa State Integrated Health Policy-2002, Government of Orissa.

Supplementary Readings:

1. International Institute for Population Sciences (IIPS). 2007–08. DLHS 3, Orissa. Mumbai: IIPS.
2. International Institute for Population Sciences (IIPS) and Macro International. 2008. National Family Health Survey (NFHS-3), India, 2005–06: Orissa. Mumbai: IIPS.
3. Patnaik, D. 1982. *Festivals of Orissa*, Bhubaneswar: Orissa Sahitya Academy.

HS 538 URBAN GOVERNANCE AND DEVELOPMENT 4 Credit (3-1-0)

Objectives: The course has both academic and practical objectives. As the principal academic objective, students should gain an understanding of how cities, suburbs, and their metropolitan areas function and are governed. As the principal practical objective, students should gain a sense of how the problems of urban areas might be better addressed by both elected policy makers and appointive public administrators. At the end of the semester, students should be better prepared to assist in solving such problems themselves. **Contents:** Urban demography, Rural urban continuum, Urban local governance, Urban planning, Poverty, Problems with slum areas, Urbanisation and its impact; origin patterns, structure, functions - Urban local institutions; constitutional framework, Urban laws - decentralization and autonomy – Wards Committee.

Essential Readings:

1. Basu, D.D, 1985, *Introduction to the Constitution of India*, New Delhi, Prentice Hall of India
2. Singh. I.B, 1997, *Administrative System in India*, IPH, New Delhi
3. Barthwal. C.P, 2002, *Understanding Local Government*, Bharat Book, Lucknow.
4. Arora. R.K, 1999, *District Administration*, Aalekh Pub., Jaipur.
5. Hoshiar Singh, 1997, *Local Government*, Kitab Mahal, Allahabad

Supplementary Readings:

1. Harrigan, John J., and Ronald K. Vogel. *Political Change in the Metropolis*, 6th ed. Addison-Wesley Longman, 2000, paper.
2. Bissinger, Buzz. *A Prayer for the City*. Vintage Books, 1997, paper.

HS 541 ECONOMICS OF DEVELOPMENT 4 credits (3-1-0)

Objective: This course will introduce students to the field of development economics by providing an in-depth knowledge of economic growth and development with primary focus on the growth model and its applicability in India. ; **Contents:** Economics of Development: Concepts and Approaches; Growth Model; Development Theories; Domestic and International Measures for Economic Development; Role of State in Economic Development; Population Growth and Economic Development; Poverty and Unemployment.

Essential Reading:

1. Taneja Mayer, *Economic Growth and Development*, Indian Publisher.
2. Benjamin Higgins, *Economic Development: Problems, Principles and Policies*, UBS Publishers
3. Debraj Ray, *Development Economics*, Oxford India Paperbacks

Supplementary Reading:

1. Brown, M.: *On the Theory and Measurement of Technical Change*.
2. Chenery, H.B. et. al. (Eds.): *Redistribution with Growth*.
3. C.P. Kindleberger, *Economic Development*, W.W. Norton & Co.; Second Edition edition
4. Maurice Dobb, *Some Aspect of Economic Development*

HS 542 POVERTY, INEQUALITY AND HUMAN DEVELOPMENT 4 credits [3-1-0]

Objective: This course aims at equipping students with the technical and substantive dimensions of various measures of poverty, inequality and human development.

Contents: Conceptual dimensions of poverty; deprivation and human development; absolute and relative poverty measures; notions of chronic poverty and socio-economic vulnerability with particular emphasis given to the role of health functioning and capability deprivation; Economic inequalities in India; Measurement of Human Development Index (HDI), Gender-related Development Index (GDI), Gender Empowerment Measure (GEM), Human Poverty Index (HPI)

Essential Reading:

1. Alkire, S. (2002) *'Dimensions of human development'*, World Development, vol 30, no 2, pp181–205

2. Anand, S. and Sen, A. (1997) *'Concepts of human development and poverty: A multidimensional perspective'*, Human Development Papers, UNDP, New York
3. Gary S. Fields. (1980). *Poverty, Inequality, and Development*, Cambridge University Press.

Supplementary Reading:

1. Atkinson, A. B. and Bourguignon, F. (2001) *'Poverty and inclusion from a world perspective'*, in Joseph Stiglitz and Pierre-Alain Muet (eds) Governance, Equity and Global Markets, Oxford: Oxford University Press.
2. Stiglitz, Joseph E. and Muet, Pierre-Alain, (2001), Governance, Equity, and Global Markets: The Annual Bank Conference on Development Economics - Europe, Oxford University Press.
3. Foster, J. E. (2006) *'Inequality Measurement'*, in D. Clark (ed.) Edward Elgar, *The Elgar Companion to Development Studies*, Cheltenham.

HS 543 GLOBAL ISSUES IN DEVELOPMENT 4 Credit [3-1-0]

Objective: This course will provide an introduction to the global issues in development confronting by both developed and developing countries. Core approach would be interdisciplinary and thematic, with special attention to cultural, economic, political, and social conflicts and patterns and their effect on development and inequality. **Contents:** Major political, economic, social, and environmental issues confronting the global community, Evaluation of demographic, economic, and ethno-national dimensions of development, interdisciplinary major with a focus on social justice, sustainable economic development, public health, global interconnection, and public service, Millennium Development Goals, Climate change and adaption policies, Demographic transition and Health policies.

Essential Readings:

1. Stiglitz, Joseph E. 2003. *Globalization and Its Discontents*. New York: Norton
2. Sachs, Jeffrey D. 2005. *The End of Poverty: Economic Possibilities of Our Time*. New York: Penguin Press
3. World Bank. 2003. *World Development Report 2003: Sustainable Development in a Dynamic World*. New York: Oxford University Press
4. World Bank and International Monetary Fund. 2003. *Global Monitoring Report 2003*. Washington, DC
5. Bhalla, Surjit. 2002. *Imagine There's No Country: Poverty, Inequality, and Growth in the Era of Globalization*. Washington, DC: Institute for International Economics.
6. Milanovic, Branko.2006. Global Inequality: What It Is and Why It Matters. Washington, DC: World Bank.

Supplementary Readings:

1. Collier, Paul, and Jan Dehn. 2001. Aid, Shocks, and Growth. Policy Research Paper 2688, World Bank, Washington, DC.
2. Rajan, Raghuram, and Arvind Subramanian. 2005. What Undermines Aid's Impact on Growth? Working Paper WP/05/126, International Monetary Fund, Washington, DC.
3. Meyer, Aubrey. 2000. Contraction and Convergence: The Global Solution to Climate Change. Totnes. United Kingdom: Green Books

HS 544 ENVIRONMENT AND DEVELOPMENT 4 Credit [3-1-0]

Objective: The course will thus teach methodological knowledge besides substantive knowledge about issues related to innovation and governance pertaining to sustainable environmental management and development. The course will also acquaint student with institutional theory and governance – how the plurality of interests is transformed into coordinated action and the compliance of actors is achieved. **Content:** Human Environment Interaction and Cultural Ecology: Human ecology, culture and ecosystem. Environmental degradation and poverty: Causes of resource degradation, Sustainable development. Climate Change and Human Adaptation, Environmental management and innovation strategies, Development: Environment and Sustainable Livelihood.

Institutional theories in Environmental Management: Governance for sustainable development. Policy responses to environmental degradation: Displacement, Social movements, Industrialization, Ecotourism and Biodiversity Management.

Essential Readings:

1. Elinor Ostrom, 1997, *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge University Press, New York.
2. Jhon Barry, 2000, *Environment and Social Theory*, Routledge, London.
3. Fikret Berkes, *Sacred Ecology* (second edition), 2008, Routledge, New York.
4. S.K Agarwal & P.S. Dubey, 2002, *Environmental Controversies*, APH Publishing Corporation, New Delhi.

Supplementary Readings:

1. Dr. I Sundar,2006, *Environment and Sustainable Development*, APH Publishing Corporation, New Delhi
2. Kartar Singh, 1994, *Managing Common Pool Resources: Principles and Case Studies*, Oxford, New Delhi

HS 545 INDIAN FINANCIAL SYSTEM 4 credits [3-1-0]

Objective: The basic objective of the course is to provide comprehensive introduction to the functioning of financial market in the emerging context of deregulation and globalization of markets. ; **Contents:** Introduction of financial System; Financial system and economy; Reforms in the financial system, Role of Indian financial system; Financial Markets and Instruments; The place of Financial markets in the Economy; Real assets and Financial assets, Money market, Capital market, Primary market, Secondary market, Government Securities market, Foreign exchange market, Debt market, and Derivative market.; Development of Financial Institution and Instrument.

Essential Readings:

1. Bhole, L.M. (2009), *"Financial Institutions and Markets: Structure, Growth and Innovation"*, Tata McGraw Hill Publishing Company Limited, New Delhi.
2. Pathak Bharati. V. (2006), *"India Financial System",* Pearson Education in South Asia Publishing Company, New Delhi.

Suggested Readings:

1. Avadhani, V.A (2000), *"Financial Economics: Theory and Practice"*, Himalaya Publishing House, Mumbai.
2. Chandra, P. (2005), *"Financial Management: Theory and Practice"*, Tata McGraw Hill Publishing Company Limited, New Delhi
3. Houthakar, H.S. and Williamson, P.J. (2000), *"The Economics of Financial Markets"*, Oxford University Press.
4. Hung, C. and Litzenberger (1998), *"Foundation of Financial Economics"*, North Holland.
5. Johnson, H.J. (1993), *"Financial Institutions and Markets"*, Tata McGraw Hill Publishing Company Limited, New York

HS 546 POPULATION DYNAMICS AND DEVELOPMENT 4 credits [3-1-0]

Objective: This course will help students to critically examine different analytical approaches of population studies and to explore interrelationships between population changes and socio-economic development ; **Contents:** Introduction to Population Studies, Sources of population data, Evaluation of quality of Demographic data; Differentials in age and sex composition; Measures of fertility, Mortality and Migration, Variations in rates and pattern of Fertility, Mortality, and Population growth, Level and trend of Urbanization, Economic interrelationship between Fertility, Mortality and Development; Socio-economic Implications of Population Ageing.

Essential Reading:

1. Bhende, Asha and Kanitkar T., (1993) *Principles of Population Studies*, Himalaya Publishing House, Bombay.
2. Srinivasan, K. (1998), *Basic Demographic Techniques and Applications*. London: Sage Publications.
3. Pathak, K.B. and F. Ram (1992), *Technique of Demographic Analysis*. Bombay: Himalaya Publishing House.
4. Drèze, J and A Sen (1995), *India: Economic Development and Social Opportunity* (Oxford: Oxford University Press).

Supplementary Reading:

1. Bulatao, R A and R D Lee. (1983) An Overview of Fertility Determinants in Developing Countries, in Bulatao and Lee (eds.) (1983) Determinants of Fertility in Developing Countries (New York: Academic Press).
2. Heerink, Nico, (2012*) Population Growth, Income Distribution, and Economic Development: Theory, Methodology, and Empirical Results*, Springer

HS 548 DEMOGRAPHIC TRANSITION AND HEALTH POLICIES IN DEVELOPING WORLD 4 credits [3-1-0]

Objective: The aim of this course is to familiarise students with the main issues in health, population and society in developing and transitional societies. ; **Contents:** Overview of the world's current demographic situation at both global and regional level; Stages of demographic transition; Demographic transition theories and their relationships to theories of socio-economic development; Major threats to health, Mortality and burden of disease; Poverty and inequalities in health; Health consequences of HIV/AIDS epidemic in developing world; Child and maternal mortality; Health issues among ageing population; Achieving good health at low cost in developing countries; Health policies to reduce mortality and diseases.

Essential Reading:

1. Alan C. Swedlund, George J. Armelagos. 1990. *Disease in Populations in Transition: Anthropological and Epidemiological Perspectives*, Bergin & Garvey
2. David E. Bloom, David Canning, Jaypee Sevilla.2003. *The Demographic Dividend: A New Perspective on the Economic Consequences of Population Change*, Rand

Supplementary Reading:

1. Nancy Birds all, Allen C. Kelley, Steven Sinding. 2001. *Population Matters: Demographic Change, Economic Growth, and Poverty in the Developing World*, Oxford University Press, 2001
2. Richard Leete. 1999. *Dynamics of Values in Fertility Change*, Oxford University.

HS 549 PUBLIC ECONOMICS 4 credits [3-1-0]

Unit-1

The Basics

1. Role of Government in Economy
2. Theory of Social goods
3. Theory of Public Choice

Unit-2

Public Expenditure

Growth and structure of Public Expenditure, Public expenditure management, cost benefit analysis of public expenditure, evaluation of public expenditure-principle and problems, subsidies

Unit-3

Public Revenue

Issues in individual income taxation, corporate taxation, income tax integration, principle of taxation, indirect taxation-principle and issues, value added tax (VAT)-principle and issues, and Non-tax revenue

Unit-4

Federal Finance

Principle of federal finance, center-state relationship

Essential Readings

1. Harvey, Rosen, Public Finance (Second Edition), IRWIN, Homewood, 1988.
2. Atkinson, A. B. and Stiglitz, J.E., Lecturer in Public Economics, McGraw-Hill, New York 1980.
3. Myles, Garesth D, Public Economics, Cambridge University Press, 1995.

Supplementary Readings

1. Boadway Robin W Wildasin David E., Public Sector Economics, (2nd Edition), Little Brown, Boston, 1984.
2. Musgrave, Richard A & Shoup, Carl S (ed), Classics of the Theory of Public Finance, Macmillan, 1962.
3. Musgrave Richard A, Fiscal System, Yale University Press, New Haven and London, 1969.

HS 550 THEORY OF MONEY, OUTPUT AND EMPLOYMENT 4 credits [3-1-0]

1. National Income Accounting

i) Meaning and Significance of Macro Economics, Difference between Micro and Macro Economics/Analysis.
ii) National Income- Accounting: Concepts-GDP,GNP, NDP, NNP, Income at market price, and income at factor cost, Income at Constant Price, Capital Income
iii) Methods of Measurement of National Income and problem associated with measurement of national income.
iv) Circular flow of income and expenditure, two, three and four sectors model
v) National Income as indicator of national welfare

2. Classical Theory

i) Classical Ideas on determination of output and employment in the short run: Say's law of Markets; classical dichotomy, quantity theory of money; Self regulation of markets and full employment and classical theory of rate of interest.

3. Keynesian Theory

i) Keynes' critique of classical theories; attack on self regulation of markets; classical dichotomy and full-employment equilibrium. Keynes theory of Effective Demand; consumption function, multiplier; Keynes theory of rate of interest- liquidity preference; theory of investment- marginal efficiency of capital. Keynes theory of prices and wages, Pigou effect and its critique.

4. Consumption Behaviour

i) Fundamental Psychological law of consumption and its implication.
ii) Determination of consumption function.
iii) Theories of aggregate consumption- life cycle hypothesis, Absolute, relative and permanent income hypothesis.

5. Demand for Money and Supply of Money

i) Definition of money; Motives for holding money; Keynesian and Friedman formulations of demand for money; transaction and portfolio balance approaches; wealth effect on demand for money
ii) Determinants of money supply; money multiplier model; instruments of monetary policy; transmission mechanism of monetary policy.

6. Theories of Inflation

i) Excess demand theories-keynsian, Inflationary Gap; Cost Push inflation-Phillips Curve

Essential Readings

1. W.H. Branson, Macroeconomic Theory and Policy, Harper and Row Publisher, New York
2. N.G. Mankiw, Macroeconomics, Worth Publishers, Sixth Edition
3. Rudiger Dornbusch and Stanley Fisher, Macro Economics, Sixth Edition, McGraw- Hills Publishers

Suggested Readings

1. David Romer, Advanced Macro Economics, Third Edition, McGraw- Hills
2. J.M Keynes, The General Theory of Employment, Interest and Money, Macmillan Press ltd.
3. Amit Bhadury, Macroeconomics
4. R.D. Gupta, General Theory of Money, Output and Employment

HS 570 ADVANCED LANGUAGE LABORATORY 4 credits [0-0-6]

Objective: The Digital Language Lab provides resources and facilities for language instruction and learning. It is an interactive, software-based, multimedia learning system that is used for imparting effective language learning skills, with the potential for learning independently at required pace and convenience. ; **Contents**: Spellings, Grammar and Sentence Structures (as individually needed); Conversation Practice and Role Playing Vocabulary Building and Vocabulary usage in specific contexts; Jargon/Register related to Economics and Business and its usage; Word exercises and Word games to enhance self-expression of the participants; Advanced Reading Skills: Increase ability to negotiate through texts of a complex or technical nature; Summarization /forming a gist. Aspects of Phonology: pronunciation practice; Group Discussion. Group & Individual Presentations – prepared and extempore; Interview Techniques; Written Communication – Formal letters, Report and Minutes writing; Business Communication games and activities; Group Project.

CS 171 COMPUTING LABORATORY – I 2 credits (0-0-3)

Objective: The aim of the course is to equip students with basic skills needed to work with computers.
Contents: Read a line of text and count the number of characters, vowels, consonants and blank spaces in it; Implementation of matrix manipulations; Programs on recursive function; Interchanging values of two variables without a third variable using arithmetic operators and also using bit-wise operators; Programs on the use of functions; Programs on Sorting and Searching; Programs on files for creating, populating and manipulating a simple database; Implementation of linked list; Implementation of other data structures; Menu driven programs.

HS 572 STATISTICAL LABORATORY 2 Credits [0-0-3]

Objective: The aim of the course is to provide training in use of various statistical packages for research purposes.
Contents: Introduction to SPSS, Data entry, Data Management, Descriptive statistics, Inferential Statistics.

SCHOOL OF MANAGEMENT

DETAILED SYLLABI OF COURSES

Sl. No.	Sub Code.	Subjects	L-T-P	Credits
1	SM 501	Organizational Behavior and Structure	3-0-0	3
2	SM 502	Human Resource Management	3-0-0	3
3	SM 503	Managerial Economics	3-0-0	3
4	SM 504	Production & Operations Management	3-0-0	3
5	SM 505	Financial and Cost Accounting	3-0-0	3
6	SM 506	Financial Management	3-0-0	3
7	SM 507	Marketing Management	3-0-0	3
8	SM 508	Quantitative Techniques and Operations Research	3-0-0	3
9	SM 509	Research Methodology	3-0-0	3
10	SM 510	Economic and Legal Environment	3-0-0	3
11	SM 511	Management Information System	3-0-0	3
12	SM 512	Technology and Innovation Management	3-0-0	3
13	SM 513	Basic Computer Lab	0-0-3	2
14	SM 514	Statistics Lab	0-0-3	2
15	SM 515	OB Lab	0-0-3	2
16	SM 516	HR Lab	0-0-3	2
17	SM 517	Business Simulation Lab	0-0-3	2
18	SM 518	Management Games Lab	0-0-3	2
19	SM 519	Seminar & Technical Writing – I	0-0-3	2
20	SM 520	Seminar & Technical Writing – II	0-0-3	2
21	SM 601	Strategic Management	3-0-0	3
22	SM 602	Business Ethics and Corporate Governance	3-0-0	3
23	SM 603	Internship	3-0-0	3
24	SM 604	Presentation and Comprehensive Viva-voce	0-0-0	3
25	SM 605	OR Lab	0-0-3	2
26	SM 606	Banking Operations Lab	0-0-3	2
27	SM 607	Leadership Lab	0-0-3	2
28	SM 608	Project Lab	0-0-3	2
29	SM 609	Language Lab	0-0-3	2
30	SM 610	Marketing Lab	0-0-3	2
31	SM 611	Seminar & Technical Writing - III	0-0-3	2
32	SM 612	Customer Relationship Management	3 0 0	3
33	SM 612	Seminar & Technical Writing - IV	0-0-3	2
34	SM 613	Consumer Behaviour and Marketing Research	3-0-0	3
35	SM 614	Customer Relationship Management	3-0-0	3
36	SM 615	Product and Brand Management	3-0-0	3
37	SM 616	Retail Management	3-0-0	3
38	SM 617	Sales and Distribution Management	3-0-0	3
39	SM 618	Industrial and Services Marketing	3-0-0	3
40	SM 619	Integrated Marketing Communication	3-0-0	3
41	SM 620	International Marketing	3-0-0	3
42	SM 621	Financial Institutions, Instruments and Markets	3-0-0	3
43	SM 622	Financial Options, Futures and Swap	3-0-0	3
44	SM 623	Commercial Banking	3-0-0	3

45	SM 624	International finance	3-0-0	3
46	SM 625	Financial Services	3-0-0	3
47	SM 626	Mergers and Acquisitions	3-0-0	3
48	SM 627	Security Analysis and Portfolio Management	3-0-0	3
49	SM 628	Insurance and Risk Management	3-0-0	3
50	SM 630	Project Planning and Appraisal	3-0-0	3
51	SM 631	Employee Relations and Labour Legislations	3-0-0	3
52	SM 632	Performance Management	3-0-0	3
53	SM 633	Human Resource Planning	3-0-0	3
54	SM 634	Organization Change and Development	3-0-0	3
55	SM 635	Training and Development	3-0-0	3
56	SM 636	Leadership for Corporate Excellence	3-0-0	3
57	SM 637	Employee Compensation and Benefits Management	3-0-0	3
58	SM 638	Strategic Human Resource Management	3-0-0	3
59	SM 640	Knowledge Management	3-0-0	3
60	SM 641	Materials Management	3-0-0	3
61	SM 642	Reliability and Risk Management	3-0-0	3
62	SM 643	Total Quality Management	3-0-0	3
63	SM 644	Supply Network Management	3-0-0	3
64	SM 645	Business Process Transformation	3-0-0	3
65	SM 646	Operations Strategy	3-0-0	3
66	SM 647	Project Planning, Scheduling and Monitoring	3-0-0	3
67	SM 648	Decision Modeling and Simulation	3-0-0	3
68	SM 651	Strategic Information System	3-0-0	3
69	SM 652	Database Management System	3-0-0	3
70	SM 653	E- Commerce	3-0-0	3
71	SM 654	Software Project and Quality Management	3-0-0	3
72	SM 655	Enterprise Resource Planning	3-0-0	3
73	SM 656	IT Strategy	3-0-0	3
74	SM 657	System Analysis and Design	3-0-0	3
75	SM 658	Software Engineering	3-0-0	3

SM 501 ORGANIZATIONAL BEHAVIOUR AND STRUCTURE 3 Credits [3-0-0]

Course Contents:
Introduction to OB; Foundations of Individual Behaviour; Values, Attitudes and Job Satisfaction; Personality and Emotions; Perception and Individual Decision Making; Motivation; Foundations of Group Behaviour; Understanding Work Teams; Leadership; Group Dynamics; Stress Management; Conflict Management, Transactional Analysis; Cross-cultural Management; Organization Culture and Climate. Organization Structure: Forms, Line and Staff Conflict, Formal & Informal Organization, Centralization & Decentralization; Span of Management, Delegation of Authority, MBO.

Essential Readings:

1. S. P. Robbins and T. A. Judge, *Organizational Behaviour*, 13/e, Prentice-Hall of India Pvt. Ltd., 2008.
2. D. L. Nelson and *J. C. Quick, Organizational Behaviour*, 5/e, Thompson, 2008.

Suggested Readings:

1. UdaiPareek, *Understanding Organizational Behaviour*, 2/e, Oxford University Press, 2008.
2. T. S. Bateman and S. A. Snell, *Management*, 8/e, TMH, 2008.

SM 502 HUMAN RESOURCE MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Concept, Nature and scope of Human Resource Management; growth and development of Human Resource Management in India; Job analysis and job design; Recruitment and Selection; Tests and Interviews; Orientation; Promotion; Transfer; Separations; Outplacement; Human resource planning; Training & Development: Concept, Training Vs Development, Learning Principle, Training need assessment and types of training programmes; Performance Management; Potential Appraisal; Career and Succession Planning; Job Evaluation; Compensation and benefits; Employees welfare, safety and health; HR Audit; HRIS; Knowledge Management.

Essential Readings:

1. Gary Dessler, *Human Resource Management*, 11/e, Pearson Education, 2008.
2. Scott Snell and George Bohlander, *Human Resource Management*, 2007.

Suggested Readings:

1. H. J. Bernardin, *Human Resource Management: An Experiential Approach*, TMH, 2007.
2. VSP Rao, *Human Resource Management: Text and Cases*, 2/e, Excel Books.

SM 503 MANAGERIAL ECONOMICS 3 Credits [3-0-0]

Course Contents:
Concept and context; Demand Analysis and Supply Analysis; Quantitative Demand Analysis and Revenue Analysis; Cost and Production Function; Price and Output Determination by the firm and Industry under various market structures e.g., Perfect Competition, Monopoly; Monopolistic Competition; Oligopoly; Business Cycle; National Income Measurement; Theories of Income Determination; Saving-Investment Analysis.

Essential Readings:

1. Keat, Young and Banerjee, *Managerial Economics*, Pearson Education, New Delhi.
2. Shappiro, *Macro Economics*, TMH, New Delhi.

Suggested Readings:

1. D.W.Carlton&J.W.Perloff, *Modern Industrial Organisation*, Harper Collins.
2. Y. Maheswari, *Managerial Economics*, PHI, New Delhi

SM 504 PRODUCTION AND OPERATIONS MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Introduction; Production and operations function and its relations to other management functions of an organization; Work system design: process planning, methods study, line balancing, work measurement, work sampling and its applications; Operations Strategy & competitiveness; Process Analysis; Manufacturing Process selection and design; Service Process selection and design; Facility Location and Facility Layout; Strategic capacity management; Aggregate sales and operations planning; Materials flow control: raw materials and WIP inventory control, JIT, lead-time control; Quality assurance and control: statistical process control, process capability improvement, sampling inspection, TQM, QC, Kaizen; Maintenance planning and management: corrective, preventive and predictive maintenance, replacement analysis; Inventory control; Operation Scheduling; Project management; Supply chain strategy.

Essential Readings:

1. Chase, Jacobs, Aquilano, Agarwal, *Operations Management*, TMH, New Delhi.
2. Mahadevan, *Operations Management- Theory and Practice*, Pearson Education, New Delhi

Suggested Readings:

1. S. N. Chary, *Production and Operations Management*, TMH, New Delhi.

2. Scott T. Young, *Essentials of Operations Management*, Sage Publication.

SM 505 FINANCIAL AND COST ACCOUNTING 3 Credits [3-0-0]

Course Contents:
Functions and objectives of Accounting; Cyclical nature of business and Accounting cycle; Golden Rule; Transactions; Balance Sheet & Income Statements; Accounting Standards. Capital and Revenue transactions; Trial Balance; Company Accounts, Authorized Share Capital, Kinds of Share Capital; Issue of share capital, preference share capital and Debentures, Financial Reporting; GAAP; Annual reports; Cash flow reporting. Basic Cost Concepts, Prime Cost & Overheads: Allocation, apportionment and absorption of overheads; Preparation of Cost Sheet; Cost Accounting Records: Cost ledger accounts, Reconciliation; Methods of Costing, Process costing, Joint Products and By-Products, Transport Costing; Marginal Costing and decision making: Marginal Costing Vs Absorption Costing, Cost-Volume–Profit Analysis, Application of Marginal Costing and Short run decision analysis; Budgets and Budgetary Control, Zero Based Budgeting; Standard Costing.

Essential Readings:

1. Narayanswamy, *Financial Accounting - A Managerial Perspective*, PHI, New Delhi
2. Charles T Homgen, G Foster and S M Datar, *Cost Accounting a Managerial Emphasis*, 10th Ed, PHI

Suggested Readings:

1. Ramachandran&Kakani, *Accounting for Management*, TMH, New Delhi
2. Banerjee, *Cost Accounting: Theory and Practice*, PHI, New Delhi

SM 506 FINANCIAL MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Introduction, Scope, Objectives & Nature of Financial Management; Role of finance manager; Sources of finance: Equity Capital, Debentures, Preference Capital and Term Loan; Cost of Capital: Time Value of Money, Concept of Risk & return; Cost of Capital & Value of firm: Measurement of specific cost of capital, Weighted Average Cost of Capital ,Valuation of stock & bonds; Financing Decision: Capital Structure theories, EBIT-EPS relationship, Determinants of Capital Structure; Leverages: Operating, Financial & Combined Leverages; Investment Decisions: Capital budgeting methods, NPV, IRR, Capital budgeting under risk & uncertainty, Capital rationing; Dividend Decisions: Forms of Dividends, Theories of dividend Polices, Determinants of Dividends Decisions, Implication of Bonus Issue, Right Issue, Stock Split and Buy back of shares; Working capital Management: Concept, Operating cycle, Estimation of working Capital requirement, Cash Management, Receivable Management, Inventory Management.

Essential Readings:

1. Van Horne, Bhaduri, *Fundamentals of Financial Management*, Pearson Education, New Delhi.
2. I.M. Pandey, *Financial Management*, Vikash Publications, New Delhi.

Suggested Readings:

1. Keown, *Financial Management: Principles and Applications*, Pearson Education, New Delhi.
2. P. C. Chandra, *Financial Management*, TMH, New Delhi.

SM 507 MARKETING MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Introduction to marketing; challenges of modern marketing; Customer value and satisfaction; Market-oriented strategic planning; Marketing Information System; Scanning the marketing environment; Buyer Behaviour; Models of Consumer Behaviour; Market segmentation; Marketing

Mix; Demand Assessment and Forecasting; and targeting; differentiation and positioning. Developing new market offerings and global market offerings; developing the product and branding strategy; services marketing; pricing policy, marketing channels & physical distribution and communication strategies; sales management; rural marketing; Internet marketing; marketing strategy implementation and control.

Essential Readings:

1. Kotler& Armstrong, *Principles of Marketing*, Pearson Education/PHI, New Delhi.
2. Philip Kotler, Keller, Koshy&Jha, *Marketing Management,* Pearson Education, New Delhi.

Suggested Readings:

1. Grewal and Levy, Marketing, TMH, New Delhi.
2. Ramaswamy&Namkumari, A Text Book of Marketing Management, Macmillan.

SM 508 QUANTITATIVE TECHNIQUES AND OPERATIONS RESEARCH 3 Credits [3-0-0]

Course Contents:

Business Statistics: Measures of Central tendency and Dispersion; Variance and Covariance; Correlation & Regression Analysis; Testing of Hypotheses: t- test, z- test, chi-square test, ANOVA. Introduction to Operations Research and Decision Theory, Structure of decision strategies, decision making under competitive situation. Introduction and use of linear programming; Graphical Method; Simplex method: Minimization and Maximization Cases. Transportation Problems: Introduction and use; North-West Corner Rule; Stepping-Stone Method; Vogel Approximation Method (VAM). Assignment Problems: Introduction and use; Hungarian Method; Balanced and Unbalanced Problems; Maximization Case. Queuing Theory: Introduction to Waiting-line Model; uses of Queuing Model; Queuing Models of different category. Game Theory: Introduction and Use; Problems solving using Dominance Theory; Problems of Mixed Strategy, PERT; CPM; Simulation, Stochastic Programming.

Essential Readings:

1. Hamdy A Taha, *Operations Research*, PHI, 7th Edition.
2. Levin and Rubin, *Statistics for Management*, PHI, New Delhi

Suggested Readings:

1. Chase, Richard B.; Aquilano, Nicholas J and Jacobs, F. Robert (9th Edition); *Operations Management For Competitive Advantage*, by Tata McGraw-Hill.
2. Anderson David R, *Quantitative Methods for Business*, 10th Ed., Cengage.

SM 509 RESEARCH METHODOLOGY 3 Credits [3-0-0]

Course Contents:

Research Methodology: Meaning, Objectives, Types, and Approaches; Identification of Research Problem; Research Design: Exploratory, Descriptive, Experimental, Observational Studies & Survey; Literature Review; Hypotheses; Sampling; Data Sources; Data Collection Tools; Reliability and Validity; Introduction to Qualitative Research Methods; Interpretation and Report Writing.

Essential Readings:

1. D. R. Cooper and P. S. Schindler, *Business Research Methods*, 9/e, TMH, 2009.
2. C. R. Kothari, *Research Methodology, 2/e*, New Age International (P) Ltd. Publishers, 2006.

Suggested Readings:

1. Alan Bryman, *Social Research Methods*, 3/e, Oxford University Press, 2009.
2. S. N. Murthy and U. Bhojanna, *Business Research Methods*, 3/e, Excel Books.

SM 510 ECONOMIC AND LEGAL ENVIRONMENT 3 Credits [3-0-0]

Course Contents:
Environment of Business, Socio Cultural and Politico Legal Environment, Changing role of government and socio economic scenario. Structure and Dimension of the Economy, Structure of the Industry, Public Sector, Small & Medium Sector, Emerging Economic Scenario, National Planning Process, Evolution of Industrial Policy, Regulatory and Promotional Framework, Foreign Trade, Balance of Payments, Export and Import Policy, Foreign Direct Investment, External Debt, Industrial Policy, Economic Reforms, Inclusive Growth. Introduction to Business Law; Law of Contract; Sale of Goods Act; Companies Act; Patents law and Enforcement; Trade Mark Law and Enforcement; Corporate Taxation, Banking Law & Practice; Negotiable Instruments Act; Transfer of Property Act; Limitation Act, Industrial Regulation and Development Act, Securities Act.

Essential Readings:

1. Baumel W J.,A S Blinder and W. M. Scarth (1985), *Economics: Principles and Policy*, Academic Process Canada, Toronto.
2. ND Kapoor, *Business Law*, Sultan Chand

Suggested Readings:

1. Swamy, D.S. (1994), *The Political Economy of Industrialization*, Sage Publications, New Delhi, Introduction, Chapter-1, and Conclusion.
2. Tulsian, *Business Law*, TMH, New Delhi

SM 511 MANAGEMENT INFORMATION SYSTEM 3 Credits [3-0-0]

Course Contents:
Management and Systems Advance in Management: The process of MIS Development MIS Organisation, Information Dynamics, Planning Design and Implementation of MIS, IS Strategic Planning MIS Design, Gross Design Concepts, Detail Design Concepts, MIS Implementation Acquiring Information Systems, Contemporary Approaches System Life Cycle: Information, Flow Entity Relationship Modeling, Data Modeling, Detailed Process Analysis, Data Flow Diagrams, Decision Making with MIS System: Concepts for MIS Data Information and Communication, Problem Solving and Decision Making IS Security, Control System Success and Failure, The Future Trends in MIS: The Emerging IT Trends Electronic Data Interchange, Objected Oriented Approach, Networking (Information System Highway), Extended Enterprise Systems, Managing International Information Systems

Essential Readings:

1. Davis & Olson, *Management Information Systems*, TMH, New Delhi.
2. O'Brein&Marakas, *Management Information Systems*, TMH, New Delhi

Suggested Readings:

1. Laudon and Laudon, *Management Information Systems Managing the Digital Firm*, Pearson Education/PHI.
2. JiawehanMichelineKamber, *Data Mining Concepts and Techniques*, Morgan Kauffman.

SM 512 TECHNOLOGY AND INNOVATION MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Evolution of Technology; Effects of New Technology; Technology Innovation: Technology development; Technology transfer; Technology Assessment; Organizational and Social Implications of Technology; Human Aspects in Technology Management; Introduction; Types and Pattern of Innovation; Innovation within the Life Cycle of a Technology; Choosing Innovation Projects; Collaborating Strategies; Protecting Innovation; Innovation Strategies ; Organizing for Innovation: Organization Structure and Culture, Managing the Innovation Process, Social Networks and

Informality in the Innovation Process; New Product Development Teams, Crafting a development strategy; Organization as a laboratory for learning.

Essential Readings:

1. R. Boutellier, O. Gassmann and M. Zedtwitz, *Managing Global Innovation - Uncovering the Secrets of Future Competitiveness*, Springer, 1999.
2. Melissa Schilling, *Strategic Management of Technological Innovation*, TMH, 2008.

Suggested Readings:

1. M. Iansiti, *Technology Integration making critical choices in a dynamic world*, Harvard Business School Press, Boston, 1998.
2. Steve Conway and Fred Steward, *Managing and Shaping Innovation*, Oxford University Press, 2009.

SM 601 STRATEGIC MANAGEMENT 3 Credits [3-0-0]

Course Contents:

An overview of company strategy; Understanding a Company: Vision, Mission, Objectives, Goals, Strategies, and Tactics, Concept and process of strategic Management, Strategic Business Unit (SBU). Environmental Scanning, SWOT analysis, Internal and External environmental analysis. Competition Analysis: Porter's Five Force Theory, Competitive Advantage, Value chain analysis. Classification of Strategies (long term vs. short term, generic, grand strategies); Strategic Planning for Competitive Advantage: Business Strategy, Corporate Strategy, Diversification, Mergers, Acquisitions, Strategic Alliances, Joint ventures, Divestment, BCG, GE Matrices; Evaluation of Strategic Alternatives and Strategy Implementation.

Essential Readings:

1. Robert Pitts, *Strategic Management: Building and Sustaining Competitive Advantage*, Cengage Learning.
2. Pearce, *Strategic Management: Formulation*, Implementation and Control, TMH.

Suggested Readings:

1. AzharKazmi, *Strategic Management and Business Policy*, TMH.
2. Hitt, Ireland and Hoskisson, *The Management of Strategy: Concepts and Cases,*Cengage Learning.

SM 602 BUSINESS ETHICS AND CORPORATE GOVERNANCE 3 Credits [3-0-0]

Course Contents:

Introduction to Business Ethics: Need, Importance, Nature, Scope, Objectives of Business Ethics, Factors influencing Business Ethics, Characteristics of Business Ethics, Ethical decision making. Corporate Governance: Issues, Need and Importance, benefits of good governance to companies and to the society. Corporate Governance Mechanism: Anglo-American Model, German Model, Japanese Model and Indian Model. Managerial Obligations to Society, Investors, Employees, Customers.Role of Board of Directors, Auditors, SEBI and Government. Growth of Corporate Governance in India; Corporate Governance Ethics; How ethics can make corporate governance more meaningful; Corporate social responsibility of business.

Essential Readings:

1. C. Fernando, *Corporate Governance: Principles, Policies and Practices*, Pearson Education.
2. Velasquez, *Business Ethics: Concepts and Cases*, Pearson/PHI.

Suggested Readings:

1. Hartman, *Perspectives in Business Ethics*, TMH.
2. Solomons, *Corporate Governance and Accountability*, John Wiley.

SM 612 CUSTOMER RELATIONSHIP MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Introduction to CRM; CRM in marketing, CRM and Customer Service; Sales force automation; Analytical CRM; Planning for CRM; CRM tools; Managing CRM project; CRM in E- business; Product and service delivery on the web, communication using the web infrastructure, data collection and analysis, personalized exchange of information with customers and new models of managing customer relationships both internal and external.

Essential Readings:

1. Zikmund, *Customer Relationship Management*, John Wiley & Sons.
2. JilliDychi, *The CRM Handbook*, Pearson Education.

Suggested Readings:

1. Bee, Frances and Roland, *Customer Care*, Universities Press.
2. Jagdish Seth, AtulParvatiyar, G Shainesh, *Customer Relationship Management: Emerging Concepts, Tools and Applications*, TMH.

SM 613 CONSUMER BEHAVIOUR AND MARKETING RESEARCH 3 Credits [3-0-0]

Course Contents:
Consumer Decision Making: four views of consumer decision making- Economic man, Cognitive man, Emotional man, Passive man; Consumer Decision process, Factors influencing consumer decision making process, Comprehensive models of consumer decision making: Nicosia Model, Howard-Sheth model, Engel-Kollat-Blackwell model. Individual determinants of behavior: Personality, perception, Attitudes, learning and motivation. Social and ethical perspective of Consumer behavior: Family influences; Social, Cultural and Developmental Influences; Consumer response to marketing-Innovation and the product Life Cycle; Consumer Behaviour and Strategy- Issues; Organizational Buying Behaviour. ; Marketing Research: The marketing research process- defining research objectives, research designs, major qualitative research techniques – Depth interview, focus group, projective techniques, specialized techniques; Sampling; Field work; Questionnaire Design; Data Analysis: Test of significance using sampling statistics, chi-square and ANOVA, correlation and regression, factor analysis for data reduction cluster, analysis for market segmentation, conjoint analysis for product design, multidimensional scaling for brand positioning. Use of data processing packages such as SPSS; Research presentation and research process evaluation.

Essential Readings:

1. Schiffman and Kanuk, *Consumer Behavior*, Pearson Education.
2. Green &Tull, *Research for Marketing Decisions*, TMH.

Suggested Readings:

1. Lauden&Bitta, *Consumer Behaviour*, TMH.
2. N. K. Malhotra, *Marketing Research: An Applied Orientation*, PHI.

SM 614 CUSTOMER RELATIONSHIP MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Introduction to CRM; CRM in marketing, CRM and Customer Service; Sales force automation; Analytical CRM; Planning for CRM; CRM tools; Managing CRM project; CRM in E- business; Product and service delivery on the web, communication using the web infrastructure, data collection and analysis, personalized exchange of information with customers and new models of managing customer relationships both internal and external.

Essential Readings:

1. Zikmund, *Customer Relationship Management*, John Wiley & Sons.

2. JilliDychi, *The CRM Handbook*, Pearson Education.

Suggested Readings:

1. Bee, Frances and Roland, *Customer Care*, Universities Press.
2. Jagdish Seth, AtulParvatiyar, G Shainesh, *Customer Relationship Management: Emerging Concepts, Tools and Applications*, TMH.

SM 615 PRODUCT AND BRAND MANAGEMENT 3 Credits [3-0-0]

Course Contents:

Product management- Introduction; Product strategy; Analysis of product line and Product mix decisions; Product life cycle; New Product development process and strategies; Product line extension; Product testing: Pre-test Marketing and Test Marketing, Launching strategies for new product. Product positioning/ repositioning strategies; Brand Management: Branding process and strategies; Building brand identity; Brand extensions and their equities; Brand portfolio management; Brand leverage; Brand image; Brand personality; Brand loyalty; Brand valuation techniques; Co-branding; Building strong brands in Indian and international contexts; Importance of Branding in terms of product success.

Essential Readings:

1. Keller Kevin, *Strategic Brand Management*, PHI
2. Lehman Donald, Russell, *Product Management*, TMH.

Suggested Readings:

1. Y L R Moorthi, *Brand Management: The Indian Context*, Vikas Publication.
2. Jean Noel Kapferer, *Strategic Brand Management*, Free press.

SM 616 RETAIL MANAGEMENT 3 Credits [3-0-0]

Course Contents:

Introduction to retailing; Retailing in India; Retail formats & theories; Phases of growth of retail markets; Retail Strategy; Understanding Retail Consumers; Retail institutions; Store Design & Layout; Retail Merchandising; Buying and Merchandising; Retail Pricing & Merchandise; Retail Operations; Measuring Retail Performance; Retail Management Information System; Retail Marketing & Communication; Service quality in Retail Sector; Design and Visual merchandising, Managing retail operations; Importance of Supply Chain Management; E-retailing.

Essential Readings:

1. Lamba A J, *The Art of Retailing*, TMH.
2. Berman & Evans, *Retail Management: A Strategic Approach*, Pearson Education/PHI

Suggested Readings:

1. Diamond, Jay and Gerald, *Retailing*, Prentice Hall.
2. Morgenstein, Melvin and Harriat Strong, *Modern Retailing*, Prentice-Hall.

SM 617 SALES AND DISTRIBUTION MANAGEMENT 3 Credits [3-0-0]

Course Contents:

Sales Management: The role of selling and sales management; Sales process; Characteristics of sales people; Sales force design; Territory management; Selection and Recruitment of sales force; Compensation and Motivation of sales force. Distribution Management: Distribution channel and their structure, Functions and Relationships, Channel Planning and Designing Channel Systems, Logistics of Distribution Channel, Evaluation and Control, Channel Conflicts.

Essential Readings:

1. Richard R. Still, Edward W. Cundiff, Norman A. P. Govoni, *Sales Management: Decisions, Strategies and Cases*, PHI.
2. K.K. Havaldar& V.M. Kavale, *Sales & Distribution Management*, TMH.

Suggested Readings:

1. S.L. Gupta, *Sales & Distribution Management*, Excel Books.
2. T. Panda and K. Sahadev, *Sales & Distribution Management*, Oxford Publication.

SM 618 INDUSTRIAL AND SERVICES MARKETING 3 Credits [3-0-0]

Course Contents:
Industrial Marketing-an overview, Concepts & systems; Dynamics of industrial buying & buyer behaviour; Industrial Marketing strategy Formulation; Product planning & New product development; Logistic & channel strategy; IM through communication planning; Pricing policies and strategies; IM environment. ; Service marketing: Origin, growth and classification of services; Emergence of Service Economy; Nature of Services; Goods and Services Marketing; Service Vision and Service Strategy; Service delivery process, pricing, promotion, positioning; Service blueprint; Customer satisfaction and service quality; Operating strategy; Hospital services, Financial services, Information Technology Services, Health care services, Services marketing in future, Marketing Challenges in service business.

Essential Readings:

1. Reeder, et al; *Industrial Marketing: Analysis*, Planning and Control, PHI.
2. Hoffman, *Services marketing: Concept, Strategies and Cases*, Cengage/Thomson.

Suggested Readings:

1. Fredrick E Webster Jr, *Industrial Marketing, Concepts and Cases*, John Wiley.
2. Zeithaml and Bitner, *Services Marketing*, McGraw Hill.

SM 619 INTEGRATED MARKETING COMMUNICATION 3 Credits [3-0-0]

Course Contents:
Situational analysis; Role of advertising in marketing mix; Positioning decisions Advertising opportunities for different product situations; Kinds of advertising; Setting of advertising objectives & planning; Formulation of strategies & budgets; Media Planning development; Media buying and research; Copy designing & testing; Evaluating advertising campaigns; Advertising research techniques; The social and economic effects of advertising; Advertising agencies; Public relations as an element of marketing mix; Various PR tools; Choosing PR message and vehicles; Ethical issues in advertising.

Essential Readings:

1. P.R.Smith and Jonathon Taylor, *Marketing Communication- An Integrated Approach,*Kogan Page.
2. Mohan Manendra, *Advertising Management- Concepts and Cases*, TMH.

Suggested Readings:

1. Kazmi and Batra, *Advertising and Sales Promotion*, Excel Books.
2. Russel and Lane, Klepnner's, *Advertising Procedure*, Pearson Education.

SM 620 INTERNATIONAL MARKETING 3 Credits [3-0-0]

Course Contents:
Introduction to International Marketing: International Marketing Environment, Preparing for International Marketing Strategies. International Marketing Mix: International Research and

Segmentation, Developing Global Products and Pricing, International Promotion and Advertising, International Distribution Systems. The Indian Export Scenario: The Export Import Scene in India, Import-Export Policy, Export Documentation, Export Procedure, International Technology Transfer and Counter Trade, The Trade Mark Regime. International Marketing Planning: Managing Systems for International Marketing, Reflection and Evaluation of the Endeavours.

Essential Readings:

1. Roger Bennett, Jim Blythe, *International Marketing: Strategy Planning, Marketing Entry and Implementation*, Kogan Page.
2. Hans Muhlbacher, HelmuthLeihs and Lee Dahringer, *International Marketing: A Global Perspective*, Thomson Learning.

Suggested Readings:

1. Philip R Cateora, John L Graham and PrashantSalwan, *International Marketing*, TMH.
2. Michael R. Czinkota, IikkaA.Ronkainen, *International Marketing*, Thomson.

SM 621	FINANCIAL INSTITUTIONS, INSTRUMENTS AND MARKETS	3 Credits [3-0-0]

Corse Contents:

Introduction to Financial System, Classification of Financial Markets, Capital Market (Primary Market & Secondary Market), Money Market, Commodity Market. Financial Markets- Indian & Global financial Markets; Financial Institutions: Money Market Institutions, Capital Market Institutions, Financial Service Institutions, Stock Exchanges: Organizations and Functions, SEBI Regulations, Securities Appellate Tribunal, Investor services, Ombudsmanship, Financial Services Institutions, Commodity Exchanges, NSDL, STC, Forward Markets Commission, Credit Rating Institutions; Financial Instruments: Money market instruments, Capital Market Instruments, Commodity market Instruments, Forex market Instruments, Mutual Funds: Types; Operations; SEBI Guidelines regarding launching Mutual funds schemes; Computation of NAV; Performance measurement of MF's; Marketing of MF products; Indian Financial Institutions: Commercial banks:- Roles, Functions, Public sector, Private Sector, Foreign Banks, Development Banks:- IFCI, IDBI, SFCs, NABARD, RRBs, SIDBI, Insurance Regulatory Development Authority (IRDA), Non-banking Financial Institutions (NBFCs), Insurance Companies: Public & Private.

Essential Readings:

1. Nasser Arshadi, Gordon V Karels, *Modern Financial Intermediaries*, PHI.
2. Guruswamy, *Financial Markets & Institutions*, Thomson.

Suggested Readings:

1. M. Y. Khan, *Indian Financial System*, TMH.
2. L. M. Bhole, *Financial Institutions, Markets and Service*, TMH.

SM 622	FINANCIAL OPTIONS, FUTURES AND SWAP	3 Credits [3-0-0]

Course Contents:

Financial Derivative: Features, Types of Derivatives; Basic Financial Derivatives; History of Derivatives Market; Use of Derivatives; Critiques of Derivatives. Traders in Derivative Markets; Calculus for derivative products; Factors contributing to the growth of Derivatives; Financial Derivatives Market in India. Introduction to Forwards, Futures, Swap, Options, and other exotic derivatives; Pricing forward contracts; The carry cost model; Pricing option contracts; Black-Scholes Model; Binomial pricing models; Risk – Neutral valuation, Volatility estimation techniques; ARCH family of models; Currency Option; Future Option; Measuring option price sensitivity; Value at risk concept and it's application; Hedging; Basic Hedging with derivative products.

Essential Readings:

1. John C Hull, Option, *Futures and Other Derivatives*, PHI.

2. Sudaresan, *Fixed Income Markets and their Derivatives*, Cengage.

Suggested Readings:

1. Robert W. Kolb, *Understanding Futures Market*, PHI.
2. Marshall &Bansal, *Financial Engineering: A complete guide to Financial Innovation*, PHI.

SM 623 COMMERCIAL BANKING 3 Credits [3-0-0]

Course Contents:

Introduction to Banking; Overview of Banking; Evolution of commercial banking, Challenges; Banker-Customer Relationships; Characteristics of Negotiable Instruments; Cheque and its characteristics; Customers' Deposit Accounts; Risk profile of financial systems; Evolving international financial markets- recent changes and their effects; Banking instruments, investment planning and capital adequacy norms; Cash management, business risk and profitability planning; Branch banking, international banking and country risk assessment; Development Banking, Banking Sector Reforms, ALM, Introduction to International Banking, Banking Technology.

Essential Readings:

1. Reed,Cotter,Gill and Smith, *Commercial Banking*, Prentice Hall.
2. B. S. Khubchandani, *Practice and Law of Banking*, Macmillan

Suggested Readings:

1. McDonald, *Management of Banking*, Cengage/Thomson.
2. Guruswamy, *Banking Theory Law and Practice*, TMH

SM 624 INTERNATIONAL FINANCE 3 Credits [3-0-0]

Course Contents:

International Financial Management- An Overview; International Flow of Funds- The Balance of payments; International Financial System & The Market for Foreign Exchanges; International Monetary Systems; Evolvement of Floating Rate Regime; Foreign Exchange Market in India; Determination of Exchange Rates- PPP & IRP; International Parity Conditions; Exchange Rate Forecasting; Managing Foreign Exchange Risk; Currency derivatives: Forwards, Swaps & Interest Parity; Currency & Interest rate futures; Currency options; Interest Rate Risk Management; International Investment & Financing; Financing the Global Firms; Foreign Investment Decisions; International Trade Finance; International financial markets & instruments.

Essential Readings:

1. Eitman, Stonehill, Mofett, *Multinational Business Finance*, Pearson Education.
2. P.G Apte, *International Financial Management*, TMH.

Suggested Readings:

1. M. D Levi, *International Finance*, TMH.
2. Giancarlo Gandolfo, *International finance and open-economy macroeconomics*, Springer

SM 625 FINANCIAL SERVICES 3 Credits [3-0-0]

Course Contents:

Financial system; Financial Markets- Meaning, Classification; Capital Market; Capital Market intermediaries; Primary & Secondary Market; Stock Exchange; Functions of Stock Exchange; SEBI Guidelines, Investor protection. Call Money Market; Commercial Papers; Treasury Bills; Certificate of Deposits; Commercial Bills; Gilt-edged Securities; Warrants and Convertibles; ADRs and GDRs; Derivatives- Options and futures. Merchant Banking; Role of Lead managers, Registrars, Underwriters, Brokers and Bankers; Capital issue management; Pre and Post Issue Management; Role of NBFCs; Leasing; Lease Evaluation and Accounting; Hire purchase concept and Financial Evaluation; Factoring and Bill Discounting; Venture Capital; Credit Rating.

Essential Readings:

1. Clifford E Kirsch, *The Financial Services Revolution*, McGraw Hill
2. M.Y. Khan, *Financial Services*, TMH

Suggested Readings:

1. Nalini P Tripathy, *Financial Instruments and Services*, PHI
2. Meir Kohn, *Financial Institutions and Markets*, Oxford

SM 626 MERGERS AND ACQUISITIONS 3 Credits [3-0-0]

Course Contents:
Various Forms of Business Alliances; Strategic Choice of Type of Business Alliance; Who should go for Merger and Acquisition and Take-over; Defining and Selecting Target; Pricing of Mergers (Pricing the Competitive Bid for Take-over); Negotiation/Approach for Merger, Acquisition and Take-over; Contracting; Implementation of Merger and Acquisition; Managing Post-Merger Issues; Legalities Involved in Merger, Acquisition and Take-over; Ethical Issues of Merger and Take-over; Accounting for Mergers; Financing the Mergers and Take-overs; Corporate Restructuring; Divestment and Abandonment.

Essential Readings:

1. Kevin K Boeh, Paul W. Beamish, *Mergers and Acquisitions*, Sage.
2. SudiSundersanam, *Value Creation from Mergers and acquisitions*, Pearson Education.

Suggested Readings:

1. Food Western, Kunag S Chung, Susan E Hung, Mergers, *Restructuring and Corporate Control,* PHI.
2. AswathDamodaran, *Corporate Finance- Theory and Practice*, John Willey.

SM 627 SECURITY ANALYSIS AND PORTFOLIO MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Concept of investment, objective and constraints; Developments of security markets in India: Primary market, Secondary market, Stock market Index & calculation methodology; Concept & Measuring of Risk and Return; Reduction of risk through diversification; Investment decision based on “alpha” & “beta”; Bond valuation, Valuation of equity shares (Dividend discount model, PE approach & DCF Model); Equity investment styles; Technical Analysis and Oscillators; Efficient market hypothesis; Method of Fundamental Analysis; Tools of Technical Analysis; Portfolio Analysis; CAPM; APT; Portfolio concepts; Markowilz’s Mean-Variance analysis; Portfolio Construction and Optimization; Portfolio performance evaluation; Portfolio revision.

Essential Readings:

1. Fischer and Jordon, *Security Analysis & Portfolio Management*, PHI.
2. Sharpe, *Alexander and Bailey, Fundamentals of Investment*, PHI.

Suggested Readings:

1. Jones, *Investments: Analysis and Management*, John Wiley.
2. Reilly, *Investment Analysis & Portfolio Management*, Cengage.

SM 628 INSURANCE AND RISK MANAGEMENT 3 Credits [3-0-0]

Course Contents:
An overview of risk and risk management: Introduction to risk and uncertainty, rationale and objectives of risk management; Risk assessment: Risk identification and measurement, pooling arrangements and diversification of risks. Insurance business and operations: Introduction to insurance, Agency Law, Principles of general underwriting and claims management, Product

management, Actuarial functions, Pricing strategies, Place and distribution strategies; Commercial Insurance Contracts: Life Insurance, Marine Insurance, Fire Insurance, Motor Insurance and Miscellaneous insurance contract; Hedging risk with derivative contracts, Relevant Case Studies in Indian context.

Essential Readings:

1. George E. Rejda, *Principles of Risk Management and Insurance*, Pearson Education.
2. Vaughan and Vallghan, *Fundamental of Risk and Insurance,* John Willey & Sons.

Suggested Readings:

1. Trieschmann, *Risk Management and Insurance*, Cengage/Thomson
2. Mishra and Mishra, *Insurance Principles & Practice,* Sultan Chand.

SM 630 PROJECT PLANNING AND APPRAISAL 3 Credits [3-0-0]

Course Contents:
Capital Investment Decisions, Project Analysis, Introduction to Capital Budgeting, Strategy and Resource Allocation, Project Screening, Technical Analysis, Product Mix, Alternatives and Implementation, Financial Estimates and Appraisals, Feasibility, Working Capital Requirements, Project Cash Flows, Risk Analysis.

Essential Readings:

1. Prasanna Chandra, *Projects Planning, Analysis, Selection, Implementation and Review*, TMH.
2. Y Khan & P K Jain, *Financial Management: Texts Problems and Cases*, TMH.

Suggested Readings:

1. Andrew Fight, *Introduction to Project Finance*, Butterworth, Elseiver.
2. Stefano Gatti, *Project Financing: Theory and Practice,*Elseiver.

SM 631 EMPLOYEE RELATIONS AND LABOUR LEGISLATIONS 3 Credits [3-0-0]

Course Contents:
Approaches to Industrial relations: Unitary, Pluralistic, and Radical approaches; Trade Unionism: Concept, Function and Structure, union registration and recognition, Trade Unionism in India. Industrial Disputes: Concept, Causes and types, procedure for settlement of disputes in India, Grievance Management. Collective Bargaining: Nature, scope and functions, Stages & Bargaining Process. Participative Management: Concept, Scope and Objectives, Workers' participation in Indian Industries, Employee Empowerment and Involvement; Industrial Discipline: Code of conduct, Code of discipline, Disciplinary action, Employee Counseling. Factories Act, 1948; Mines Act 1952; Contract Labour (Regulation and Abolition) Act, 1970; Trade Union Act, 1926; Industrial Employment (Standing Orders) Act, 1946; Industrial Disputes Act, 1947.

Essential Readings:

1. C. S. VenkatRatnam, Industrial Relations, Oxford University Press, 2006.
2. P. R. N. Sinha; IndubalaSinha and S. P. Shekhar, Industrial Relations, Trade Unions, and Labour Legislation, Pearson Education, 2004.

Suggested Readings:

1. Mamoria; Mamoria and Gankar, *Dynamics of Industrial Relations*, Himalaya Publishing House, 2007.
2. P. L. Malik, *Handbook of Labour and Industrial Law*, 12/e, Eastern Book Company, 2009.

SM 632 PERFORMANCE MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Performance Management: Nature, Scope, Importance, Benefits, Process; Performance Planning; Performance Management; Performance appraisal: Methods and Approaches of performance appraisal, Obstacles in appraisal, Designing appraisal for better results, Performance appraisal interview. Potential Appraisal; Performance monitoring; PM Strategy: Career based, Team based, Culture based, Measurement based, Competency based and Reward based. Competency Mapping; 360 feedback; Assessment centers; Performance review; Coaching and counseling and Performance Management in some selected industries.

Essential Readings:

1. T. V. Rao, *Performance Management and Appraisal Systems*, Response Books, 2009.
2. S. R. Kandula, *Performance Management: Strategies, Interventions and Drivers*, PHI, 2006.

Suggested Readings:

1. R. L. Cardy, *Performance Management*, PHI.
2. Armstrong and Baron, *Performance Management*, Jaico Publishing House.

SM 633 HUMAN RESOURCE PLANNING 3 Credits [3-0-0]

Course Contents:
Job Analysis; HR Planning: Concept, Importance, Objectives, Types of HR plan, Dimensions of Human Resource Planning; Approaches-Social Demand Approach, Rate of Return Approach and Manpower Requirement Approach. HRIS and HRP; Human Resource Reporting, Computerized HRIS. Methods of demand forecasting and supply forecasting at micro level; Managing surplus and shortage; Evaluating HRP effectiveness. Career planning: Concept, Objective; Career planning vs. Human resource planning; Career planning vs. Succession planning, Process of career planning and career development, Human Resources Evaluation: Human Resources Audit and Human Resource Accounting, Succession planning.

Essential Readings:

1. Monica Belcourt and Kenneth J. McBey, *Strategic Human Resource Planning*, 2/e, Thomson, 2004.
2. Dipak Kumar Bhattacharyya, *Human Resource Planning*, 2/e, Excel Books, 2006.

Suggested Readings:

1. Gordon Mcbeath, *The Handbook of Human Resource Planning: Practical Manpower Analysis Techniques for HR Professionals*, Atlanta.
2. William J. Rothwell and H. C. Kazanas, *Planning and Managing Human Resources*, Jaico Publishing House.

SM 634 ORGANIZATION CHANGE AND DEVELOPMENT 3 Credits [3-0-0]

Course Contents:
Organizational Change: Concept, Forces demand organizational change - External and Internal, Recognizing the need for change, Problem diagnosis, Identifying alternate change techniques, Resistance to change, The process of organizational change. Managing change and Transformation: Planning, Creating the support system, managing the transition, organizational Restructuring, reorganizing work activities, strategies, process oriented strategies, competitor and customer oriented strategies. Team work; Effective Change Leader; Change Management Competencies and its development. Organization Development: OD process, OD Interventions, Action Research Orientation, Evaluating OD Effectiveness.

Essential Readings:

1. Cummings and Worley, *Theory of Organization Development and Change*, Cengage Learning, 2005.
2. Jones, *Organizational theory, design and change*, Pearson Education

Suggested Readings:

1. Nilakant and Ramnarayan, *Managing Organizational Change*, Response Books.
2. Kavita Singh, *Organization Change and Development,* Excel Books.

SM 635 TRAINING AND DEVELOPMENT 3 Credits [3-0-0]

Course Contents:
Introduction: Socializing, Orienting & Developing Employees, Teaching & Training, Training & Learning, Transfer of learning, Trainers & Training Style; Strategizing training; Training Need Analysis; Methods & Techniques of delivering training; Training Delivery; Training Interventions and Learning Experiences; Management Development: Designing Programme, Process and Techniques; Business Games; Case Study & Role Plays; Use of Films & Tales; Training Evaluation & Follow up; Impact Analysis & Return on Investment; Special Issues in Training and Employee Development.

Essential Readings:

1. Raymond A. Noe, *Employee Training and Development*, 4/e, TMH, 2008.
2. Lynton and Pareek, *Training for Organizational Transformation (Part -1 & 2)*, Sage Publication.

Suggested Readings:

1. Irwin L. Goldstein and J. Kevin Ford, *Training in Organizations*, Thomson Learning, 2007.
2. A.Mayo, *Creating a Training and Development Strategy*, Universities Press.

SM 636 LEADERSHIP FOR CORPORATE EXCELLENCE 3 Credits [3-0-0]

Course Contents:
Introduction and overview; Nature and importance of leadership; traits, motives and characteristics of leaders; charismatic and transformational leadership; leadership behaviours, attitudes and styles; contingency and situational leadership; leadership ethics and social responsibility; power, politics and leadership; influence tactics of leaders; motivation and coaching skills; creativity, innovation, and leadership; communication and conflict resolution skills; developing leadership diversity; leadership development, succession and followership; creating vision and strategic direction; shaping cultures and values. Group dynamics: cohesion and development, structure, influence, performance, decision making. Designing and leading a learning organization; leading change.

Essential Readings:

1. Richard L. Daft, *Leadership*, Cengage Learning, 2005.
2. Robert J. Allio, *Leadership: Myths and Realities*, TMH, 2008.

Suggested Readings:

1. D. R. Forsyth*, Group Dynamics*, Thomson, 2007.
2. G. Vijayaragavan, *High Performance Leadership,* HPH, 2007.

SM 637 EMPLOYEE COMPENSATION AND BENEFITS MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Conceptual Framework of Compensation Management; Theories of wages; Job Evaluation; Wage and Salary Administration; Wage Differentials; Wage Structure; Wage Fixation; Employee compensation; Incentive Payment and types of incentive plans. Compensation practices of

multinational and global organizations. Incentive based pay systems, Executive compensation Practices of MNCs. Legal Aspect: Minimum Wages Act, 1948, Payment of Wages Act, 1936, Payment of Bonus Act, 1965, Equal Remuneration Act, 1976, Workmen's Compensation Act, 1923, Employees' State Insurance Act, 1948, Employees' Provident Funds and (Miscellaneous Provisions) Act, 1952, Payment of Gratuity Act 1972, Maternity Benefit Act, 1961.

Essential Readings:

1. G. T. Milkovich and J. M. Newman, *Compensation*, 8/e, TMH, 2007.
2. Joseph J. Martocchio, *Strategic Compensation*, Pearson Education, 2007.

Suggested Readings:

1. Henderson, *Compensation Management in knowledge based world*, Pearson Education.
2. P. L. Malik, *Handbook of Labour and Industrial Law,* 12/e, Eastern Book Company, 2009.

SM 638 STRATEGIC HUMAN RESOURCE MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Overview of Business Environment & Strategic Management; Strategic management & HR linkages; Concept of Strategic HRM; Models of SHRM; SHRM & Organizational Success; Process of Strategic HRM; Formulating & Implementing HR Strategy; Strategy & OD; Strategic HR & Change Management; Strategy and Culture; Strategic HR & Recruitment; Strategic HR & Performance Management; Strategic HR & Employee Development; Strategic HR & Reward Management; Strategic HR & Employee Relations; Strategic Employee Retention, Restructuring and Strategic HR.

Essential Readings:

1. Mabey, Salaman and Storey, *Strategic Human Resource Management*, Sage Publication.
2. Dreher Dougherty, *Human Resource Strategy*, TMH, 2005.

Suggested Readings:

1. C. R. Greer, *Strategic Human Resource Management,* Pearson Education.
2. TanujaAgarwala, *Strategic Human Resource Management*, Oxford University Press, 2008.

SM 640 KNOWLEDGE MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Knowledge Management: Introduction, Scope, Techniques, Principles, Types, Process; Drivers of KM; Knowledge at the environmental and organizational level; Building knowledge organization: Cultural and Strategic Imperitives; Technology and KM; HR and KM; Cross Functional Areas and KM; Team structures and KM; Organizational Dimension and KM; Learning Organizations; Enabling organizational transition into a knowledge enterprise; Role of human resources in creating knowledge organizations; Implementing KM at the enterprise level.

Essential Readings:

1. Donald Hislop, *Knowledge Management in Organizations: A Critical Introduction*, Oxford University Press, 2007.
2. Ganesh Natarajan and SandhyaShekhar, *Knowledge Management*, TMH.

Suggested Readings:

1. Sue Brelade and Chris Harman, *A Practical Guide to Knowledge Management*, Viva Books Pvt. Ltd., 2006.
2. B. Rathan Reddy, *Knowledge Management*, HPH, 2007.

SM 641 MATERIALS MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Introduction to materials management; Developing MPS; Materials requirement planning: MRP process, Bill of materials; Capacity management: Capacity planning, Capacity requirement planning (CRP), Capacity available, Capacity required, Scheduling orders; Production activity control: load leveling, theory of constraints and drum-buffer rope; Purchasing: Selecting suppliers, Impact of materials requirements planning on purchasing; Aggregate materials management; Supply and demand patterns; Order quantities: Economic order quantity (EOQ), Variations in EOQ, Quantity discounts; Order quantity under uncertain demand and uncertain lead time; Lot sizing rules: Fixed order quantity (FOQ), Lot-for-Lot (LFL), Fixed period requirement (FPR), Periodic order quantity (POQ), Least unit cost (LUC), Least total cost (LTC), Part period balancing, Wagner-Whitin algorithm; Analysis of lot-sizing heuristics: Groff method, Silver meal method, Wagner-Whitin method, Freeland-Colley method; Vendor rating and source location; Negotiations in purchasing; Stores function and inventory management.

Essential Readings:
1. J R Tony Arnold, Stephen N Chapman, Lloyd M Clive, *Introduction to Materials Management*, Prentice Hall.
2. Gupta and Chitale, *Materials Management: Text & Cases*, PHI.

Suggested Readings:
1. Lee and Dobler, *Materials and Purchasing Management*, Mc-Grawhill.
2. Menon K. S., *Purchasing and Inventory Control*, Wheeler.

SM 642 RELIABILITY AND RISK MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Reliability; Enhanced Reliability; Hazard analysis; Data sources; The human connection; The computer connection; Risk analysis; Estimation of risk; Risk assessment; Risk assessment and public policy; Failure to danger Human reliability: quantitative and qualitative assessment, Human factors in system design, Outcomes and consequences, Ionizing radiation, Harm and risk, Quantitative risk analysis: limitations and uses, Risk assessment and cognition: thinking about risk, Risk assessment in occupational health and safety, Risk management and communication: decision-making and risk, Safety management principles and practice.

Essential Readings:
1. Peter J Edwards and Paul A Bowen, *Risk Management in Project Organisations*, UNSW Press.
2. Sue Cox and Robin Tait, *Safety, Reliability and Risk Management: An Integrated Approach,* Elsevier Science

Suggested Readings:
1. Kit Sadgrove, *The Complete Guide to Business Risk Management*, Grover Publishing Limited.
2. Evgueni D Solojentsev, *Scenario Logic and Probabilistic Management of Risk in Business and Engineering*, Springer.

SM 643 TOTAL QUALITY MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Introduction: Meaning & evolution of quality concepts, views of quality issues, cost of quality; TQM concepts and key elements; Scope of TQM; Japanese approach to TQM; Concept of Kaizen and Continuous Improvement; Quality Management System and ISO-9000; Tools and techniques for process improvement, Peoples Issues in TQM; Leadership Issues, Total Employee Involvement, 5S Concept; Quality Circles and its Relevance; TQM implementation and improvement initiatives;

Quality system standards; Total productive maintenance; Six sigma approach; Criteria for business performance excellence (MBNQA and EFQM).

Essential Readings:

1. James R. Evans and William M. Lindsay, The Management and Control of Quality, Thomson Learning.
2. Dale H. Besterfield, Carol Besterfield, Glen H. Besterfield and Marry Besterfield, Total Quality Management, PHI.

Suggested Readings:

1. Frank M, Gryna, Richard C. H. Chua, Joseph A. Defeo, *Juran's Quality Planning & Analysis for Enterprise Quality*, Tata McGraw Hill.
2. Gittow, H, Openheim A and Oppenheim R., *Quality Management*, McGraw Hill.

SM 644 SUPPLY NETWORK MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Logistic management: functions and basic issues, Indian scenario; Areas of logistical decision making, Design of transportation network; Warehousing; Introduction to e-commerce; Performance measurement of Supply Chain Management. Supply Chain Management: Genesis, definitions and basic structure; Purchasing in SCM; Logistics in SCM; Manufacturing in SCM; Sales and Marketing in SCM; Planning demand and supply; Value chain concept; Relevant issues in supply chain; Strategy formulation; Product type- Supply chain matrix; Strategic sourcing and management of supply chain; Inventory in supply chain; Suppliers evaluation and development; Outsourcing strategy; Measuring performance in supply chain.

Essential Readings:

1. R.P.Mohanty and S.G.Desmukh, *Supply Chain Management Theories & Practice*, Biztantra
2. Janat Shah, *Supply Chain Management Text and Cases*, Pearson Education.

Suggested Readings:

1. D. K. Agarwal, *Text Book of Logistics and Supply Chain Management*, Macmillan.
2. Ballou, *Business Logistics/ Supply Chain Management*, Pearson Education.

SM 645 BUSINESS PROCESS TRANSFORMATION 3 Credits [3-0-0]

Course Contents:
Overview of Process Innovation, Process and Information, Overview of Process Change, Creating a Process Vision, Understanding and Improving Existing Process, Designing and Implementing the New Process and organization, Implementation of Innovative Business Processes, Process Innovation with Information Technology, Innovation Strategies for Typical Process Types, Customer Operations, Management Processes,

Essential Readings:

1. Thomas H Davenport, *Process Innovation Reengineering Work Through Information Technology*, Harvard Business School Press.
2. Grover Varun, M Lynne Markus, *Business Process Transformation*, M.E. Sharpe.

Suggested Readings:

1. Varun Grover, William J Ketingger, *Business Process Change, Reengineering Concepts, Methods and Technologies*, Idea group.
2. Michael Hammer & James Champy, *Reengineering the Corporation: A Manifesto for Business Revolution*, Harper Collins Business Essentials.

SM 646 OPERATIONS STRATEGY 3 Credits [3-0-0]

Course Contents:
Concept and principles of operation strategy; Introduction to decision categories and role of technology; Capacity and Facilities strategies; Supplier management; Logistics system and Supply chain; Organization and Human resources; Workforce Teams; Competing on cost, Competing on quality and Competing on time; Outsourcing strategies; Strategic services operations and Services supply chain.

Essential Readings:
1. Slack and Lewis, *Operations Strategy*, Prentice Hall.
2. Van Mieghen, *Operations Strategy: Principles and Practice*, Dynamic Idea.

Suggested Readings:
1. David A. Garvin, *Operations Strategy: Text and Cases*, Prentice Hall – Gale.
2. David Walters, *Operations Strategy*, Macmillan.

SM 647 PROJECT PLANNING, SCHEDULING AND MONITORING 3 Credits [3-0-0]

Course Contents:
Introduction to project Planning and Scheduling, Project Ideas: Generation Tools for identifying investment opportunities, Project Screening: Project Rating Index, Purpose of Planning, Concepts & Tools in Planning & Scheduling, Strategic planning, Operational Control planning, Steps in Project planning and Scheduling, CPM/PERT, planning process overview, Monitoring Environment,

Essential Reading:
1. Gregory T Haugan, *Project Planning & Scheduling*, Management Concepts.
2. P. Chandra, *Projects: Planning, Analysis, Selection, Financing, Implementation, and Review*, TMH

Suggested Reading:
1. Jack Gido, *An Introduction to project Planning*, Industrial Press.
2. Maylor, H., *Project Management*, Pitman Publications.

SM 648 DECISION MODELING AND SIMULATION 3 Credits [3-0-0]

Course Contents:
Integer programming and its application in managerial decision-making; Solution methodologies; Zero-one programming; Dynamic programming: Principle of optimality, Concepts of state and stage, Solution of discrete and continuous dynamic programming problems, Introduction to Markov process. Queuing Theory: Definitions & Classification, Birth & Death process, Single & Multiple server queues, Application of queuing analysis in decision making. Discrete-event Simulation: Generation of random numbers, Simulation of queuing, Inventory and Maintenance Systems, Validation of Simulation Models, Concept of Multi Criteria decision making. Stochastic Decision Making Models: Decision Tree, Introduction to Stochastic Programming Model.

Essential Readings:
1. Stephen G. Powell and Kenneth R. Baker, *The Art of Modeling with Spreadsheets*, John Wiley & Sons.
2. David R. Anderson, Dennis J. Sweeney and Thomas A. Williams, *Introduction toManagement Science*, Thomson Learning.

Suggested Readings:
1. Render, *Quantitative Analysis for Management*, PHI.
2. Anderson, Sweeney and Williams, *Quantitative Methods for Business*, Thomson Learning.

SM 651 STRATEGIC INFORMATION SYSTEM 3 Credits [3-0-0]

Course Contents:
Introduction and Overview: From Human Decision making to DSS, DSS Architecture, Decision Modeling and Analysis, Decision Support Developments, Executive Information Systems, Data Warehousing, Access, Analysis, Mining and Visualization; Group Decision Support Systems: Goals of Group Decision Support Systems, Group versus Individual Activities, Types of Group DSS, Negotiation Support Systems; Intelligent Decision Support Systems: Knowledge-based Decision Support Systems, Knowledge Acquisition and Validation, Knowledge Representation, Inference Techniques; Decision Making Under Uncertainty: Understanding Risk in Making Decisions, Managerial Risk Taking and Organizational Decision Making, Modeling Uncertainty; Advanced Techniques: Neural Network Fundamentals, Neural Network Architecture, Simple Neural Network Applications, Genetic Algorithm, Fuzzy Logic, Fuzzy Sets in Decision Making, Intelligent Software Agents and Creativity; System Integration and Future of DSS.

Essential Readings:

1. Turban and Aronson, *Decision Support Systems and Intelligent Systems*, Pearson Education.
2. George M. Marakas, *Decision Support Systems*: In the 21st Century, PHI.

Suggested Readings:

1. V S Janakiraman, K Sarukesi, *Decision Support Systems*, PHI.
2. B Ravindranath, *Decision Support Systems and Data Warehouses*, New Age.

SM 652 DATABASE MANAGEMENT SYSTEM 3 Credits [3-0-0]

Course Contents:
Concepts of DBMS and RDBMS: Mathematical Definition of a relation, Candidate Key and Primary Key of a Relation, Foreign Key; Relational Operators, Insertion, Deletion, Update operations of a relation, Attribute, domain and their Implementation; Data Models: Object based logical models, Record based Logical Model, Network model, Hierarchical Model; Data Abstraction: Physical Level, Logical Level, View level; Data Independence; Normalization: Introduction, 1NF, 2NF, 3NF, BCNF, SQL: Codd's Rules; PL/SQL: Procedure & Function; Trigger; Components of Form Designer using windows; controls and Properties; Building Sample Application; Report Designer: Building the project Reports; Database Administration with Oracle: Storage structure and Access method definition; Physical organization modification, Granting of authorization for data access, Integrity constraint specification, Role of DBA; Security mechanisms: Need for security, Physical and Logical security, Design Issues, Maintenance Issues, Operating system Issues and Availability, Accountability, Integrity; Back-up and recovery mechanisms: Logical Backups, Physical Backups, Online backups, rollback, standby database, Recovery manager, Parallel Recovery.

Essential Readings:

1. Kahate, *An Introduction to Database Management Systems*, Pearson Education.
2. R. Ramakrishna, *Database Management System*, TMH.

Suggested Readings:

1. Gerald, *Database Management System*, TMH.
2. Rob, *Database Systems: Design Implementation & Management*, Cengage/Thomson

SM 653 E-COMMERCE 3 Credits [3-0-0]

Course Contents:
Introduction to e-commerce – Traditional Commerce vis-à-vis e-commerce; Internet & WWW; Web portals; Economic forces & e-commerce; Value chains in e-commerce; Infrastructure for e-commerce; Web based tools for e-commerce: E-commerce tools and Software; The environment of e-commerce: Principals of e-commerce (B2B, B2C); Security Issues for e-commerce; Implementing

security for e-commerce; Electronic payment system; Electronic assisted strategies for Marketing and Sales promotion; Systems and Strategies for purchasing and support activities; Strategies for web auctions, Virtual Shopping; International, Legal, Ethical and Tax issues; Business plan for implementing e-commerce

Essential Readings:

1. Kenneth C. Laudon and Carol G. Traver, *Electronic Commerce*, Pearson Education.
2. P. Gary Schneider and James T. Perry, *Electronic Commerce*, Thomson Learning Press.

Suggested Readings:

1. David Whitely, *e-Commerce*, McGraw Hill.
2. Joseph, *E-commerce – An Indian Perspective*, PHI.

SM 654 SOFTWARE PROJECT AND QUALITY MANAGEMENT 3 Credits [3-0-0]

Course Contents:
Introduction: The software Engineering discipline-evolution and impact; emergence of software engineering; notable changes in software development practices. Software Life Cycle Models and Waterfall Model; Classical Waterfall Model; Other SDLC Models; Software Project Management; Project Estimation Techniques; COCOMO: A Heuristic Estimation Technique; Software Configuration Management; Software Design; Function-Oriented Software Design; Object-Oriented Software Design; Software Testing; Software Reliability and Quality Management; Computer Aided Software Engineering; Software Maintenance and Reuse.

Essential Readings:

1. Roger S Pressman, *Software Engineering: A Practitioner's Approach*, McGraw Hill International.
2. Rajib Mall, *Fundamentals of Software Engineering*, PHI.

Suggested Readings:

1. Jessica Keyes, *Software Engineering Handbook*, Boca Raton.
2. Kan Stephen H, *Metrics and Models in Software Engineering*, Pearson Education.

SM 655 ENTERPRISE RESOURCE PLANNING 3 Credits [3-0-0]

Course Contents:
Business Functions, Processes and Data Requirements; Development of ERP Systems; Marketing Information Systems and Sales Order Process; Production and Supply Chain Management; Management Information System; Accounting in ERP Systems; Human Resource Processes with ERP; Process Modeling, Process Improvement, and ERP Implementation.

Essential Readings:

1. Ptak, Carol A. and Eli Schargenheim, *ERP*, St. Lucie Press, NY.
2. F.R. Jacubs, *Why ERP? A Premier on SAP Implementation*, TMH.

Suggested Readings:

1. Monk, *Concept in Enterprise Resource Planning*, Cengage/Thomson.
2. Alexis Leon, *ERP*, TMH.

SM 656 IT STRATEGY 3 Credits [3-0-0]

Course Contents:
Introduction, Challenges with information as a resource, IT Decisions & Principles ; Information Intensity Matrix, Architecture, Infrastructure, Business Application Needs ; Investment and Prioritization, IS Strategy Formulation, Assessing Business Needs ; Top-Down Approaches, Bottom-

Up Approaches, Inside Out Approaches, IS Strategy Formulation Process, IT Governance, Linking Governance to Environments, IT Environments and link to governance structures, Mechanisms to implement governance ; Decision Making Structures, Alignment processes (SLAs, chargeback), COBIT/ITIL Frameworks

Essential Readings:

1. Peter Weill and Jeanne W. Ross*, IT Governance, How Top Performers Manage IT Decision Rights for superior results*; HBS Press, 2004.
2. Michael J Earl, *Management Strategies for Information Technology*, Prentice Hall.

Suggested Readings:

1. ParagKulkarni and PradeepChandle, *IT Strategy for Business*, Oxford Univeristy
2. A Brown, *Creating a Business Based IT Strategy*, Kluwer.

SM 657 SYSTEM ANALYSIS AND DESIGN 3 Credits [3-0-0]

Course Contents:
Introduction to Systems and System Analysis; Information System Components; Business Information Systems; Organizational Structure; Responsibilities of System Analyst; Steps in System Analysis; System Development Life Cycle (SDLC) Models: Waterfall Model, Spiral Model; Tools of System Analysis and Design: Flowcharts, Pseudo-codes; Data Flow Diagram (DFD); Entity-Relationship diagram; Systems planning; System Analysis; Systems Design; System Implementation; Systems Operation & Support.

Essential Readings:

1. Charles S Wasson, *System Analysis, Design and Development Concepts, Principles, and Practices*, Wiley-Interscience.
2. Gary B Shelly, Harry J Rosenblatt, *Systems Analysis and Design*, Cenegage.

Suggested Reading:

1. V. Rajaraman, *Analysis and Design of Information Systems*, PHI.
2. Cashman, Shelly and Rosenbelt, *System Analysis and Design*, Thomson Learning.

SM 658 SOFTWARE ENGINEERING 3 Credits [3-0-0]

Course Contents:
Software Life Cycle Models, Managing software projects, Project management concepts, Software process and Project metrics, Software Project Planning, Risk Analysis and Management, Project scheduling and tracking, Software Quality Assurance, Software Configuration Management. Conventional methods for software engineering, System Engineering, Requirements Analysis and Specifications, Analysis Modeling, Design Concepts and principles, Architectural design, User Interface Design, Component level Design, Software Testing Techniques, Software testing Strategies, Software Reliability, Technical metrics for software, CASE tools, Software Maintenance, Software Reusability. Object oriented software engineering: Object Oriented Concepts and principles, Object Oriented analysis, Object Oriented Design, and Object Oriented testing, Technical metrics for Object Oriented Systems.

Essential Readings:

1. R. S. Pressman, *Software Engineering A Practitioner's Approach*, McGraw Hill Publications, 2006.
2. R. Mall, *Fundamentals of Software Engineering*, Prentice Hall of India, 2nd Ed, 2006.

Suggested Readings:

1. I Sommerville*, Software Engineering*, Pearson Education, Asia, 2006.
2. P.Jalote, *An Integrated Approach to Software Engineering*, Narosa, 2006.

National Institute of Technology, Rourkela

Kantajhar, Rourkela-769008

Phone: 0661-2462031

Fax: 0661-2462022

email:ar-acad@nitrkl.ac.in

www.nitrkl.ac.in