NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA

CURRICULA AND SYLLABI

- B.Tech
- M.Tech Dual Degree




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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 B. Tech and M. Sc 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 UG 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

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PHILOSOPHY OF OUR 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. The 4-year B. Tech programme shall consist of approximately 210 credits of instruction including lectures, tutorials, practical and design work, project, and special academic activities. The two year M.A. / M. Sc programme shall cover between 100 and 110 credits, while the 5 year integrated M. Sc and M. Tech programmes are expected to contain about 260 credits.

In the global context, B. Tech programme containing 210 credits may appear too heavy. A close examination of the curricula will, however, reveal that nearly 22 of the 210 credits are dedicated to co-curricular and research activities such as physical education, seminar and technical writing, SIRE, research projects and comprehensive viva-voce that contribute to a student's personality growth without taking the time to the same extent as the hard academic credits of other subjects. Further, as per our academic traditions in India, supplementary reading, as a fraction of the total academic content of a course, is normally well below that in European or American universities. In the opinion of the NIT Senate, the curriculum prescribed strikes a judicious balance between need for formal instruction and free time to think beyond the course work.

The undergraduate 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 – (3-0-0) 3 credits, (3-1-0) 4 credits and (0-0-3) 2 credits. Teachers are expected to package appropriate volume of teaching material in a subject to justify one of these three modes. Finely split subjects, carrying one or two credits, and super heavy courses carrying 4 credits or more, have been consciously avoided to ensure easy and convenient implementation.

The total teaching duration in a week is divided into several "slots" in the time table. Wednesday mornings have generally been kept free to facilitate compensatory classes as well as departmental and institute level meetings by faculty. That leaves enough time to cover five theory and four laboratory subjects in a semester. Thus, typically, a student shall study maximum 40 theory courses and 32 laboratory or design subjects in a four year B. Tech programme. The actual distribution of subjects shall stand close to what is given below making provision for 10 credit project work, 4 credit seminar & technical writing course and other non traditional components of an academic programme.

Theory Courses

Type of Course	No. of Courses	Credits
Foundation Courses (1st& 2nd Year):	12	42-44
Professional Core Courses:	10 – 12	36-40
Professional Electives:	10	30-34
Open Electives:	6	18
Total:	**38 – 40**	**126-136**

Practical/ Design Courses

Type of Course	No. of Courses	Credits
Foundation Laboratories (1st & 2nd Years):	10	20
Professional Laboratory Courses:	10	20
Analytical or Computer based Design Courses:	10	20
Total:	**30**	**60**

Miscellaneous Subjects

Type of Course	No. of Courses	Credits
Extra Academic Activity:	2	4
Short term Industrial/Research Experience (SIRE):	1	2
Seminar & technical writing:	2	4
Project work:	2	10
Comprehensive Viva-Voce:	1	2
	Total:	**22**

The above table gives the general guideline, different departments organizing their curricular load around these values. A similar scheme has been proposed for the 2 year and the 5 year integrated M.Sc./ M.A. programmes.

Common courses taught mainly during the first year of study shall consist of: (a) the basic science subjects: Chemistry, Physics and Biology, (b) Mathematics with at least one Computing Laboratory course, (c) Mechanical/Electrical Workshop practice, (d) Computer Language, (e) English including language laboratory, (f) Engineering Drawing and (g) Basic Engineering Courses such as Engineering Mechanics, Basic Electrical and Electronic Engineering, Basic Materials Engineering, Basic Thermal Engineering and Environmental Engineering etc. Limited amount of choice shall be offered to departments and to students within a department in choosing the subjects of study.

A noteworthy feature of the new curriculum is the choice of the basic science courses in first year B. Tech/M.Sc. programme. Multiple courses will be offered in Physics, Chemistry and Life Science, and a student shall choose the required number of courses honouring some necessary constraints. While all courses will carry the same credit value, the content and character of the courses will vary. The variation in contents may be in terms of mathematical vs descriptive approach, traditional vs modern topics or fundamental science vs applications. While every attempt should be made to make the contents equally challenging, depending on the aptitude and previous training, a student may find difference in difficulty level among courses.

The course distribution will be subject to certain beneficial constraints, among them:

- **a.** At least 2 of the 6 open electives (8 in case of 5 year Integrated M.Sc. and 4 in case of 2 year M.Sc.) shall be in the area of Management or Humanities and Social Sciences.
- **b.** If a student gets F grade in an elective subject and needs to register once again, he may change the elective subject, subject to other relevant constraints and consent of faculty adviser. This facility is ordinarily not available for core courses.
- **c.** In the case of an inter-institutional credit transfer, a sub-committee of the Senate may identify substitution courses from the NITR curriculum. While an exact overlap of contents is desirable, the Senate shall be free to pick up a widely different subject, if it is considered prudent in the interest of academic pursuit.

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 <specialisation name> [Course Nos.: AA 391 and AA 392, 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 391) and another in an even semester (AA 392). 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 393 and AA 394:] Similar to special topics AA 391 and AA 392 except that the latter are for theory courses, while the special laboratories cover practical, design and CAD courses.
3. Engineering Product Development Project I & II (Course Nos.: AA 395 and AA 396): These two curses with 4 credits each have been designed to give opportunity to students and teachers to work on development of

real hardware or software products from 3rd Year B. Tech onwards. A student is expected to work under the supervision of a faculty member on a project whose details are announced by the latter and approved by the Departmental Academic Committee in advance. During the semester, the student is expected to do in depth study, design, fabrication and testing, maintaining accurate record of his work for continuous mid-semester and end- semester evaluation. The student is expected to put in similar, if not higher, amount of scholastic effort as in another theory course of the same credit value. Success of the product is desirable, but not essential to get a good grade. The same product may be developed by the same student(s) over 4 semesters (Vth – VIth semesters under these courses and VIIth – VIIIth semesters under Research Projects (AA 491 and AA 492) and/or by other students in the same or in different semesters.

4. Research Project I & II (AA 491 and AA 492): Undergraduate research is receiving increasing emphasis in institutions of higher learning. It is an important component of NIT Rourkela's curriculum. The total credits shall be 10 which may be split as 6+4 or 4+6 credits at the discretion of the department. Other details are given in the regulations.

Undergraduate 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.

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.

5. Seminar & Technical Writing (AA 493, AA 494): These two subjects are introduced in the final year of B. Tech. and 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.

6. Short Term Industrial and Research Experience (SIRE) [AA 495]

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 B. Tech and M. Sc students. In exceptional cases, a project may be carried out within the Institute; but that is discouraged.

7. Comprehensive Viva-Voce [AA 496]

Graduates and 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.

8. Emphasis on Quantitative Approach

Quantitative analysis is often considered the corner stone of engineering education. In fact, in our country, universities often offer both B. Tech. and M. Sc. degrees 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.

9. 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, MALTLAB), 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.

10. 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.

11. 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 a 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.

REGULATIONS FOR THE B.TECH. PROGRAMME

The B.Tech. programme of NIT Rourkela is governed by the undergraduate regulations approved by the Senate and the Board of Governors. 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 ans subsection numbers given in this chapter refer to the corresponding section numbers in the original document.

3. Academic Calendar

3.1. 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.

3.2. 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.

3.3. 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 the situation so demands. Such suspended classes may or may not be compensated on a weekend/holiday as per decision of the Director.

3.4. 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.

4. Course Structure

4.1. The duration of the course leading to B.Tech. Degree will ordinarily be four years. A student may, however, opt for the slow pace programme if he does not feel comfortable with the work load. Under certain cases, e.g., poor grades, he is required to proceed in slow pace to minimize the time required to complete the programme.

4.2. The curricula for the different degree programmes as proposed by the respective departments and recommended by the Under-graduate Programme and Evaluation Committee (UGPEC) 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.

4.3. i. 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. 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.

ii. 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.

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

iv. 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.

v. Large classes, e.g., those of first year courses, will be divided into several sections, each section being taught by one teacher. [A single teacher may handle more than one section of the same course.] Teachers of all sections of a subject will form the coordination committee for the course which will collectively take all decisions on the course. The Head of the Department will choose one of the members as the Chairman of the Committee.

vi. Student feedback on courses assists a teacher to improve the contents and delivery. It is the duty of every student to give his thoughtful response to the questions.

4.4. The prescribed coursework shall be grouped under 3 heads – core courses, professional electives and open electives. The core courses, not to exceed 50% of the course load will cover all essential skills associated with a given department. Professional electives will be taken from a list prescribed by the department, covering courses from the same and allied disciplines. These courses shall reflect the different specialized topics in a field including the latest developments taking place around the world. Open electives shall cover courses from any department of the Institute. They will generally be, but not limited to, broad based courses that will widen the knowledge horizon of the students.

There shall be no batch-wise segregation of students in any course. All courses will be open to students of all years if they satisfy the pre- and co- requisites. In particular, open electives and departmental electives shall have students from many batches. A given course may be a core subject for one department and an elective for another. Final and pre-final year UG students may take PG (MTech and MSc) courses as electives where the departmental curriculum so permits.

4.5. In each of the first two semesters, there shall be two credits for Extra Academic Activity (EAA) / Physical Education consisting of at least 3 hours activity per week. The EAA may be N.S.S., N.C.C., Sports or any other physical activity. The detailed instructions will be imparted and practice supervised by the concerned faculty and/or officers. EAA course shall have syllabi, instruction and examination like any other course. The class timing of the EAA courses will be chosen differently from academic courses, depending on weather conditions.

The Senate may, at its discretion, recommend EAA courses as electives in higher semesters. Higher semester EAA activities may be NSS, NCC, sports or cultural activity of superior standard. Only those students who have shown special aptitude or leadership in a particular extra academic activity will be permitted by Dean (AA) / Director to register in an EAA course in a higher semester.

4.6. The curricula to be followed in the first two semesters by the students of all disciplines shall be almost common. The Senate may alter the contents of 1st year curriculum for any branch keeping the total academic (credit) load unchanged.

4.7. The curricula for B.Tech. course will include a programme of “Short term Industrial or Research Experience (SIRE)” of 8 weeks duration after the 6th semester. The experience may be obtained in any reputed industry, research laboratory, IIT, NIT and any other organization of comparable repute. The place of work has to get prior approval of the Department. On completion of the programme, the student shall submit a report to the department, which will earn 4 credits in the 7th semester. For certain branches of study, the Senate may prescribe additional practical work and study tours. Detailed procedure for administration of SIRE is given in the regulations.

In special circumstances (e.g., a 6th semester student who needs to write a supplementary examination or attend a summer course), the total period of 8 weeks may be split into 2 parts to be completed during the same or different vacation (including summer vacation after 8th semester) periods.

4.8. Under special circumstances, a student may be permitted by the Senate, or by the Chairman Senate on behalf of the Senate, to carry out a mini-project of 8 weeks duration at NIT Rourkela in lieu of the external experience. Such a project, should preferably be based on a real life industrial or social problem, under the supervision of a faculty member.

4.9. In addition to regular course work and SIRE, a B. Tech. student must carry out a major project in final year under the guidance of one or two supervisors. The Project work will carry a total of 10 credits between 7th& 8th Semesters, the distribution being 4 & 6 (or 6 & 4) credits respectively.

4.10. Every programme shall provide a “Seminar and Technical Writing” course [2 credits] during the 7th and 8th 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.

4.11. 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.

4.12. Summer Course: If the number of F or UR grades in a subject taught in autumn or spring semester is significant, a department may offer the course during the summer vacation. When a summer course is offered, it will be compulsory for all students who have secured an ‘F’ grade in that subject. There will be no alternative mid semester or supplementary examination in that course. Students who need to sit for supplementary or alternative mid semester exams on medical, family calamity or any other reason except poor academic performance may sit in the corresponding exams of the summer course, without attending classes if they satisfy the attendance requirement.

The summer courses will be identical in scope and manner of execution to the corresponding courses of regular semesters, except that the number of class hours per week may be higher. Attendance requirement will also be identical. The examinations will be conducted by the Academic section in the usual manner.

Summer courses will be announced around the middle of the spring semester. Registration for the courses will be done towards the end of the spring semester. Students securing F grades in Spring semester courses may be permitted to register within one week of starting of classes.

Teachers of spring semester courses in which summer courses have been announced will make an effort to publish the grades early, particularly for students who have secured less than 25 out of the 50 points already examined (Mid semester + Teacher’s assessment). For the benefit of the students, the grades may be displayed on doors of teacher’s rooms and announced on Institute’s web site or communicated to students by any other means.

It is the student’s responsibility to enquire about grades of courses in which he has performed poorly. No separate examination will be arranged for students who miss the summer course, or any other examination.

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

5. Registration

5.1. Every student in undergraduate programme is required to be present and register at the commencement of each semester on the date fixed and notified in the Academic Calendar.

The registration process has 3 components:

i. Physical presence of the student in campus on the first day of semester,

ii. Payment of semester fees including any unpaid dues of past semesters, and

iii. 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 Faculty Advisor.

5.2. 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 (if applicable) 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.

5.3. 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 outlined in Clause 5.8.

v. Not been struck off from the rolls of the Institute.

5.4. 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 40 credits of courses prescribed for the two semesters, i.e., secure ‘P’ or higher grade in at least 40 credits of prescribed courses,

ii. Obtain a Cumulative Grade Point Average (CGPA) of not lower than 5.70 (considering all courses including those in which the student has secured an F grade).

The method for calculating SGPA and CGPA is illustrated in Appendix–II of the regulations.

If the CGPA at the end of the First year is between 5.00 and 5.69, the student may be permitted to suspend his studies and resume it in the following year along with the next batch of students. In the repeat year, he must attend classes and be treated at par with fresh students, with no memory of grades in the previous year. The B.Tech.programme must be completed within 6 years of the original admission. However, if the CGPA is less than 6.00 in the repeat year, the student must leave the Institute.

5.5. While registering for 3rd, 5th or 7th semester, a student may register for backlog papers of 1st, 3rd or 5th semester respectively and while registering for 4th, 6th or 8th semester, he/she may register for backlog papers of 2nd, 4th or 6th 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.

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.

If a student has completed 8 semesters of study but has a few F grades still left, he must register for them as full time courses and attend classes if time table permits, instead of only writing exams as backlog papers. The entire programme must be completed within 6 years.

5.6. A student can register for a full suite of courses of the 5th, 6th, 7th or 8th semester provided he/she has obtained at least Pass (P) Grade in all subjects of 1st, 2nd, 3rd or 4th semester respectively; i.e., for registering in the full list of courses of any semester beyond 4th semester, a student must have cleared ALL courses studied two years earlier. If he still does not clear papers due 2 years earlier he has to formally register for the courses and attend classes. In such a case he gets full credits for the course as per his performance without the penalty of 1 step in grade as applicable to supplementary exams and backlog papers. He will, however, be ineligible for medals and prizes, which are based on academic performance. In case of elective courses, he may change the courses if he so desires. The Faculty adviser will help him in selecting courses for registration considering the students’ academic ability and possible timetable conflicts. Starting with the lowest level courses (due two or more years earlier) he may take courses up to the current semester, the total credit load being lower than that of a normal student. The student and his faculty advisor must check the time table before deciding the courses.

If a student gets a CGPA less than 6.00 in three consecutive semesters, he must leave the Institute. Therefore, it is in a student’s interest to estimate his own capability and register under a slow pace mode from third semester onwards, or even from the First semester. Faculty Advisors will help students in choosing the course load that is just right for each student separately.

5.7. (i) It is necessary for a student to maintain a CGPA equal to or above 6.00 at all times. If the CGPA falls below 6.00 he should enter a slow pace programme in his own interest. The following procedure will be used to make "slow pace" mandatory for a student with poor performance.

A modified grade point average called MGPA will be computed by replacing all F and X grades by P grades. If the MGPA equals or exceeds 6.00, he may be permitted to register for a full suite of higher semester courses at the discretion of Faculty Advisor. If the MGPA remains below 6.00 the student must enter a slow pace programme.

(ii) If a student scores CGPA (Not MGPA) below 6.00 in three consecutive semesters, he must leave the Institute.

(iii) In case of a First Year student, if the CGPA is between 5.00 and 5.69, he will re-register in the First Semester and start the programme afresh. The CGPA in the repeat year must exceed 6.00, else the student has to leave the Institute.

(iv) If CGPA is less than 5.00, a student must leave the Institute.

Grade	**At the end of First Year**	**For Higher Year Students**
MGPA >= 6.00	To register in 3rd semester with full suite of courses.	To register in higher semester with full suite of courses
5.70 <= CGPA < 6.00 and MGPA < 6.00	To register in 3rd semester in slow pace.	To register in higher semester in slow pace, the number of courses being decided by Faculty Advisor. To leave the Institute if CGPA falls below 6.00 in three consecutive semesters.
5.00 <= CGPA <= 5.69	To get readmitted to First Year.	
CGPA < 5.00	To leave the Institute	

5.8. Ordinarily a student is not permitted to re-register in a course when he has secured a "P" or higher grade. But it is allowed for students who have secured a CGPA below 6.00 and need to improve their score. It is not possible to improve the score in a course by writing examinations only. This clause can help a student to avoid the possibility of leaving the Institute under provisions of Clause 5.9 (ii).

There shall be no reduction of grade when a student registers for a course and attends classes, even if it is a repeat course. The student, however, becomes ineligible for medals and prizes, which are based on academic performance.

5.9. The provisions of sections 5.7 and 5.9 will continue to be valid even after a student has attended classes for 8 semesters.

5.10. A student must pay full semester fees till he clears all courses even if he is registered for no course or one course only in a particular semester, or the number of semesters he has registered in exceeds 8. [A situation of "zero course" registration shall arise when a student has cleared all courses except some belonging to the even semester.]

5.11. The classes of all semesters will start from the day following the registration, or any other date decided by the Senate.

5.12. 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. Those who have been awarded grade UR ("unregistered") because of poor attendance or for any other reason need to register for the course and attend classes as per rules.

6. Attendance and Leave

6.1. a. Unlike many examining universities, NIT Rourkela's academic programme is based primarily on the teaching-learning process. Attendance in classes, participating in classroom discussions and participating in the continuous evaluation process are the most essential components 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.

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 Academic Section. 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. Attendance in these classes are also mandatory for the students

6.2. 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 6.3, 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.

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% (approximate) 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% (approximate) (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 to write supplementary examination if offered or register 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 cut off date before every examination to compute the missed classes.

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

g. If a student is engaged officially outside the classroom, e.g, in a placement programme, an institute level meeting or in a specially approved SAC activity, his attendance will be marked by the concerned faculty or officer and communicated to the academic section. It is the student's responsibility to ensure that the attendance is marked and sent to the Academic Section.

6.3. 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 up to a maximum of 10 working days total per semester on recommendation of Faculty Advisor and Head of the Department on one of the following grounds :

i. Illness of the student 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. Because the 15 % relaxation in attendance includes some days for short illnesses, the first five days of recommended medical rest in a semester shall not qualify for medical leave.

ii. A family calamity demanding absence of the student. [Documentary proof is to be submitted by the student if asked for.]

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 in a semester.)

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.)

v. For officially arranged placement programmes on recommendation of Professor, T & P. (Limited to 5 working days in a semester.)

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.

7. Assessment of Performance

7.1. There will be continuous assessment of a student's performance throughout the semester and grades will be awarded by the Subject Teacher / Coordination Committee formed for this purpose.

7.2. 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.

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

ii. For theory subjects, the subcomponents and the respective weights assigned to these are given below.

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

iii. For assigning marks in Teacher's Assessment (T.A.), performance in home assignments, class tests, tutorials, 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.

iv. In case of students given an F, I or X grade, the teacher must submit the marks under T.A. head to the Department Office for use in future.

v. For assignment of marks in the laboratory component (P – component) the relevant subcomponents that are to be considered are: day-to-day work, regularity, tests (recommended): one test in 2 credit practical course) 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, 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 laboratory or theory courses.

7.1. The eight-week programme on industrial or R&D experience (SIRE) undergone by the students in the summer vacation will be assessed in the 7th semester. The students are required to submit written reports on the programme and give a seminar, on the basis of which a grade will be awarded. The students are also required to submit to the Head of the Department or to the faculty member in-charge, a completion certificate in the prescribed form from the competent authority of the organization where the work was done, without which he/she will not be assessed.

SIRE shall also include credit for industrial tours organized by the Institute during the first seven semesters of a student's career. The marks will be distributed in the ratio: 75% for summer work and 25% for industrial tours.

8. Examinations

8.1. a. The Examination office of the Academic Section will centrally conduct the Mid-semester and End-semester Examinations in respect of theory subjects unless otherwise arranged. The Institute shall provide sick room facility 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.

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 will be provided by the Institute. It is the course teacher's responsibility to recommend the material to be provided, and to check with the Examination office that the arrangement has indeed been done. While normal scientific calculators are permitted, other electronic devices such as programmable calculators and calculators containing communication devices are forbidden. Any exception to these provisions must be specially approved by the Senate.

All question papers submitted by the teachers will be treated as "confidential documents" till the end of the examination of the subject concerned. It is an open document after the examination is over. The institute will archive question papers in physical and electronic form, and make them available to future students.

b. The answer scripts will be dispatched by the examination office to the Subject Teacher (Examiner) on the same day or on the immediate next working day of the examination. If the concerned examiner is not available on that day, the copies will be handed over to the respective Heads of the Department (or Department office) who will pass on the copies to the concerned examiners at the earliest. It is the joint responsibility of the subject teacher (examiner) and the HOD to ensure that the scripts are examined and the grades submitted before the due date.

c. In order to provide an additional opportunity to the students who failed (obtained an 'F' grade) in one or more subjects in the Autumn and/or the Spring Semester in a year, Supplementary Examinations equivalent to the End-Semester Examination arranged centrally by the Examination Office will be conducted (before commencement of the next session) every year. Regulations relating to the Supplementary Examination are given in Appendix–XII. Supplementary examination will be offered only if there are at least 5 students appearing or if there is some other compelling reason.

8.2. a. A student will be permitted to appear in an examination, only if he/she has:

i. Attendance record as per section 6 of 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 or Chairman coordination committee.

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 / Chairman, Coordination Committee, if his/her

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.

8.3. A student will be permitted to appear in the examinations in only those subjects for which he/she has registered at the beginning of the semester and has not been debarred.

8.4. i. 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 / coordination committee of the subject. If due to any compelling reason (such as participation in national / international events with due approval of the institute, his/her illness, calamity in the family, etc.) a student fails to meet any of the requirements within/on the scheduled date and time, the teacher/coordination committee may take such steps (including conduction of compensatory tests/examinations) as are deemed fit.

ii. a. Appearing both at the Mid-Semester and End-Semester Examination of theory courses is compulsory. Normally, if a student fails to appear in the Mid-Semester Examination without any valid reason he/she should get zero for that component. If his case is examined and cleared as per Clause 8.4 (ii) (c), the student will be permitted to sit for Alternative Mid-Semester examination in the same or following year. In such cases, the grade will be reduced by one step, but not below the grade P. In deserving cases, the student may be given full credit only if he has a 95% attendance in the course.

b. If a student misses the End-Semester Examination due to compelling reason like participation in an national / international event with due approval of the Institute, serious illness of himself or a calamity in the family, he may appeal to the Dean, Academic Affairs, through his faculty advisor and Head of the Department for permitting him to appear at the Supplementary Examination(s) if offered subject to fulfilling if attendance requirement. [See Appendix XII of the regulations for rules on supplementary exams]

c. A student must apply in Form AC/113 to appear in an alternative mid semester or supplementary end semester examination.

If it is medical ground, the student has to submit the medical certificate from the Institute Doctor or the recommendation of the Institute Doctor for treatment elsewhere. In case of treatment outside the Institute (including hospitals referred by the Institute), the student must produce all medical documents (discharge certificate, prescriptions, visit slips, pathological reports, medicine purchase receipts etc.) in original. The reason for leaving the campus must also be genuine and with permission of competent authority. In case of family calamity the student's application must be supported by a letter from the parent/guardian along with copies of documents such as medical records, death certificates (if that happens).

The student will be given an 'I' grade (Incomplete) till the alternative mid semester and supplementary examinations are conducted. On availability of the grades from the teacher, the Examination office will reduce the grades by 1 step, except for those students who have a 95% attendance record. Full credit is admissible only in case of students having 95% attendance in the subject and writing supplementary examination after missing the end semester examination.

In case of prolonged illness of a student, if he/she misses both the End-Semester Examination and its Supplementary if any, the student must register for the courses as backing papers. In that case the student shall be awarded I grade till he clears the papers.

8.5. 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.

9. Project Work

9.1. The project is an important component of the Institute's B.Tech. Programme. It gives an opportunity to the student to express his/her creative talents and prepare for his future career.

9.2. The Departmental Academic Committee will invite research topics for U.G. projects from its own faculty (including adjunct faculty) and from other departments across the Institute at the beginning of the 6th semester. One member of the faculty 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. A co-supervisor from other departments, industry or other institutions may also be accepted.

9.3. The Departmental Academic Committee will assign research topics to students towards the middle of the sixth semester (preferably before January 31), after taking into consideration the requirements of the projects and choice of the students.

9.4. Each topic may be taken by a single student or a team of two students. In case of specially challenging problems, larger teams may work on a single problem, with prior approval of Dean(AA).

9.5. B.Tech. projects may be analytical, computational, experimental or developmental or combinations 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.

9.6. Each team of students, consisting of one or more members and working on a single problem, will be given an official "Project Record Book" by the Institute. Guidelines for Project Book are given in Appendix-III of the regulations. 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.

9.7. The student is required to submit formal project reports at the end of 7th and 8th semesters; that submitted at the end of the 8th 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. The departments, at the discretion, may invite external members to viva voice Boards.

9.8. For the purpose of assignment of a grade, the following will be weightage of the different components in each semester.

Mid Semester assessment by Supervisors (Based on day to day work and record book)	=	20%
Mid Semester assessment by Evaluation Boards (Based on record book only)	=	20%
End Semester assessment by Supervisors (Based on day to day work and record book)	=	20%
End Semester Assessment by Evaluation board (Through oral presentation, viva-voce, and record book)	=	20%
Project Report (assessed by Evaluation Board)	=	20%

9.9. 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:

a. Rewriting of report and submission for evaluation,

b. Extension of time for completion of the work (the time duration is to be specified),

c. Complete repetition of the project in the following year.

d. The resubmitted thesis will be evaluated by the Committee and the grade will be sent to the examination office.

9.10. Students are encouraged to work on research topics with a potential for creation of new technologies and issue of patents. Forms IP/3 and IP/4 may be filled up by the students.

Rights to all intellectual property generated in 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.

10. Graduation Requirement

10.1. In order to qualify for a B.Tech. degree of the Institute covered under these Regulations, a student must:

a. Complete all the credit requirements for the degree, as laid down in the prescribed curriculum of the discipline, with a minimum grade 'P' scored in every subject.

b. Obtain a CGPA of 6.00 or higher at the end of the semester in which he/she completes all the requirements for the degree.

c. Have cleared all dues of the Institute, the Hall of Residence, the Library, the Department, NCC, NSS and Student Activity Centre.

10.2. The minimum total credit requirements that has to be satisfactorily completed for the award of B.Tech. degree will vary between 210 – 215 depending on the course structure of various departments or as decided by the Senate from time to time.

10.3. Normally a student should complete all the requirements consecutively in eight semesters for B.Tech. degree. Academically weaker students may be granted time up to 6 years (12 semesters) to complete all the requirements for the degree. However, in special cases the Senate may further extend this limit for completion of all requirements for the degree to 7 years (14 semesters), depending upon the merit of the case, particularly for students with superior attendance record and/or record of contributing to the Institute's academic or cultural life.

CURRICULUM

CURRICULA OF B.TECH. & M.TECH. DUAL DEGREE PROGRAMME

DEPARTMENT OF BIOTECHNOLOGY AND MEDICAL ENGINEERING

Curriculum of B.Tech. (Medical Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Mathematics – I		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		15-5-15	30

SECOND SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Mathematics – II		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		**15-5-15**	**30**

THIRD SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MA 201	Mathematics - III	3-1-0	4
2	BM 201	Anatomy and Physiology	3-0-0	3
3	LS 201	Biochemistry	3-1-0	4
4	EE 243	Analog Electronics	3-1-0	4

5		HS & Open Electives – I		3-0-0	3
6	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
7	EC 270	Basic Electronics Laboratory	OR	0-0-3	2
	EE 270	Basic Electrical Engineering Laboratory			
8	BM 271	Anatomy and Physiology Laboratory		0-0-3	2
9	LS 271	Biochemistry Laboratory		0-0-3	2
TOTAL					**26**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects		L-T-P	Credits
1	MA 202	Mathematics-IV		3-1-0	4
2	EC 202	Digital Electronics		3-0-0	3
3	BM 202	Clinical Science		3-1-0	4
4		Professional Elective - I		3-0-0	3
5		HS & Open Elective – II		3-0-0	3
6	EC 270	Basic Electronics Laboratory	OR	0-0-3	2
	EE 270	Basic Electrical Engineering Laboratory			
7	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
8	BM 282	Clinical Science Laboratory		0-0-3	2
9	EC 276	Digital Electronics Laboratory		0-0-3	2
TOTAL					**25**

FIFTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	BM 311	Medical Signal and Signal Processing	3-1-0	4
2	BM 321	Biomaterials	3-1-0	4
3		Professional Elective – II	3-1-0	3/4
4		Professional Elective – III	3-1-0	3
5		HS &Open Elective – III	3-0-0	3
6	BM 381	Biomaterial Laboratory	0-0-3	2
7	BM 383	Biomedical Signal Processing Laboratory - I	0-0-3	2
8		Elective Laboratory – I	0-0-3	2
9		Elective Laboratory – II	0-0-3	2
TOTAL				**25/26**

SIXTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	BM 312	Biomedical Instrumentation	3-1-0	4
2	BM314	Biomedical Image processing	3-1-0	4
3		Professional Elective- IV	3-0-0	3
4		Professional Elective- V	3-0-0	3

5		HS &Open Elective- IV	3-0-0	3
6	BM 382	Biomedical Image Processing Laboratory	0-0-3	2
7	BM 384	Biomedical Instrumentation Laboratory	0-0-3	2
8		Elective Laboratory – III	0-0-3	2
		Elective Laboratory – IV	0-0-3	2
		TOTAL		**25**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	BM 421	Tissue Engineering	3-1-0	3
2		Professional Elective - VI	3-1-0	3/4
3		Professional Elective – VII	3-1-0	3
4		HS &Open Elective – V	3-0-0	3
5	BM 481	Tissue Engineering Laboratory	0-0-3	2
6	BM 483	Computational Biomechanics Laboratory	0-0-3	2
7	BM 471	Bioprocess Design Laboratory	0-0-3	2
8	BM 491	Research Project– I	0-0-6	4
9	BM 493	Seminar and Technical Writing– I	0-0-3	2
10	BM 495	Short term Industrial/Research Experience	0-0-3	2
		TOTAL		**26/27**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Elective–VIII	3-0-0	3/4
2		Professional Elective–IX	3-0-0	3
3		Professional Elective–X	3-0-0	3
4		HS &Open Elective–VI	3-0-0	3
5	BM 472	Biomicrofluidics Laboratory	0-0-3	2
6	BM 482	Computer Aided Tissue Engineering Laboratory	0-0-3	2
7	BM 492	Research Project–II	0-0-9	6
8	BM 494	Seminar and Technical Writing – II	0-0-3	2
9	BM 496	Comprehensive Viva Voce	0-0-0	2
		TOTAL		**26/27**

DEPARTMENT OF BIOTECHNOLOGY AND BIOMEDICAL ENGINEERING

Curriculum of B.Tech. (Biotechnology Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Mathematics – I		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		**15-5-15**	**30**

SECOND SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Mathematics – II		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		**15-5-15**	**30**

THIRD SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MA 201	Mathematics– III	3-1-0	4
2	BM 201	Anatomy and Physiology	3-0-0	3
3	LS 201	Biochemistry	3-1-0	4
4	LS 203	Microbiology	3-0-0	3

5		HS & OpenElective–I		3-0-0	3
6	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
7	EC 270	Basic Electronics Laboratory	OR	0-0-3	2
	EE 270	Basic Electrical Engineering Laboratory			
8	LS 271	Biochemistry Laboratory		0-0-3	2
9	LS 273	Microbiology Laboratory		0-0-3	2
TOTAL					**25**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects		L-T-P	Credits
1	MA 202	Mathematics–IV		3-1-0	4
2	BM 232	Biofluid Mechanics		3-1-0	4
3	BM 244	Cell and Molecular Biology		3-0-0	3
4		Professional Elective–I		3-0-0	3
5		HS &OpenElective–II		3-0-0	3
6	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
7	EC 270	Basic Electronics Laboratory	OR	0-0-3	2
	EE 270	Basic Electrical Engineering Laboratory			
8	BM 272	Biofluid MechanicsLaboratory		0-0-3	2
9	BM 274	Analytical Biotechnology Laboratory		0-0-3	2
TOTAL					**25**

FIFTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	BM 331	Bioheat and Mass Transfer	3-1-0	4
2	BM 341	Genetic Engineering	3-1-0	4
3		Professional Elective– II	3-0-0	3
4		Professional Elective– III	3-0-0	3
5		HS & OpenElective–III	3-0-0	3
6	BM 375	Bioheat and Mass transfer Laboratory	0-0-3	2
7	BM 371	Cell and Molecular Engineering Laboratory	0-0-3	2
8		Elective Laboratory – I	0-0-3	2
9		Elective Laboratory – II	0-0-3	2
TOTAL				**25**

SIXTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	BM 352	Biochemical Engineering	3-1-0	4
2	BM 354	Bioseparation	3-1-0	4
3		Professional Elective – IV		3/4
4		Professional Elective – V	3-0-0	3

5		HS & Open Elective – IV	3-0-0	3
6	BM 372	Bioseparation Laboratory	0-0-3	2
7	BM 374	Biochemical Engineering Laboratory	0-0-3	2
8		Elective Laboratory – I	0-0-3	2
9		Elective Laboratory – II	0-0-3	2
		TOTAL		**25/26**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	BM 441	Protein Engineering	3-0-0	3
2		Professional Elective – VI		3/4
3		Professional Elective – VII	3-0-0	3
4		HS & Open Elective – V	3-0-0	3
5	BM 471	Bioprocess design Laboratory	0-0-3	2
6	BM 473	Food Technology Laboratory	0-0-3	2
7	BM 481	Tissue Engineering Laboratory	0-0-3	2
8	BM 491	Research Project – I	0-0-6	4
9	BM 493	Seminar and Technical Writing – I	0-0-3	2
10	BM 495	Short term Industrial / Research Experience	0-0-3	2
		TOTAL		**26/27**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Elective – VIII		3/4
2		Professional Elective – IX	3-0-0	3
3		Professional Elective – X	3-0-0	3
4		HS &Open Elective – VI	3-0-0	3
5	BM 472	Biomicrofluidics Laboratory	0-0-3	2
6	BM 484	Structural Biology Laboratory	0-0-3	2
7	BM 492	Research Project– II	0-0-9	6
8	BM 494	Seminar and Technical Writing - II	0-0-3	2
9	BM 496	Comprehensive Viva Voce	0-0-0	2
		TOTAL		**26/27**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subjects	L-T-P	Credits	Offered to*
1	BM 202	Clinical Science	3-1-0	4	BT
2	BM 203	Clinical Biochemistry	3-0-0	3	#
3	BM 205	Clinical Microbiology	3-0-0	3	#
4	BM 232	Biofluid Mechanics	3-1-0	4	BM
5	BM 234	Biothermodynamics	3-0-0	3	#
6	BM 242	Immunology	3-0-0	3	#
7	BM 244	Cell and Molecular Biology	3-0-0	3	BM

8	BM 252	Bioenergetics & Metabolism	3-0-0	3	BT
9	BM 254	Bioprocess Calculation	3-0-0	3	#
10	BM 256	Enzymology	3-0-0	3	#
11	BM 271	Anatomy and Physiology Laboratory	0-0-3	2	BT
12	BM 272	Biofluid Mechanics Laboratory	0-0-3	2	BM
13	BM 273	Clinical Biochemistry Laboratory	0-0-3	2	#
14	BM 274	Analytical Biotechnology Laboratory	0-0-3	2	BM
15	BM 275	Clinical Microbiology Laboratory	0-0-3	2	#
16	BM 311	Medical Signal and Signal Processing	3-1-0	4	BT
17	BM 312	Biomedical Instrumentation	3-1-0	4	BT
18	BM 313	Biological Control System	3-0-0	3	#
19	BM 314	Biomedical Image Processing	3-1-0	4	BT
20	BM 315	Laser & Fiber Optics in Medicine	3-0-0	3	#
21	BM 316	Biosensors and Biotransducers	3-0-0	3	#
22	BM 321	Biomaterials	3-1-0	4	BT
23	BM 322	Biopolymers	3-0-0	3	#
24	BM 324	Surface Engineering of Biomaterials	3-0-0	3	#
25	BM 331	Bioheat and Mass Transfer	3-1-0	4	BM
26	BM 332	Biomechanics	3-0-0	3	#
27	BM 341	Genetic Engineering	3-1-0	4	BM
28	BM 342	Applied Cell Biology	3-0-0	3	#
29	BM 343	Bioinformatics	3-0-0	3	#
30	BM 345	Animal Tissue Culture	3-0-0	3	#
31	BM 352	Biochemical Engineering	3-1-0	4	BM
32	BM 353	Pharmaceutical Technology	3-0-0	3	#
33	BM 354	Bioseparation	3-1-0	4	BM
34	BM 356	Bioinstrumentation and Process Control	3-1-0	4	#
35	BM 358	Bioreactor Analysis andDesign	3-0-0	3	#
36	BM 361	Agricultural Biotechnology	3-0-0	3	#
37	BM 362	Plant Tissue Culture	3-0-0	3	#
38	BM 370	Bioinformatics Laboratory	0-0-3	2	#
39	BM 371	Cell and Molecular Engineering Laboratory	0-0-3	2	BM
40	BM 372	Bioseparation Laboratory	0-0-3	2	BM
41	BM 373	Environmental Biotechnology Laboratory	0-0-3	2	#
42	BM 374	Biochemical Engineering Laboratory	0-0-3	2	BM
43	BM 375	Bioheat and Mass Transfer Laboratory	0-0-3	2	BM
44	BM 376	Bioprocess Instrumentation Laboratory	0-0-3	2	#
45	BM 378	Animal Cell Culture and Immuno technology Laboratory	0-0-3	2	#
46	BM 381	Biomaterial Laboratory	0-0-3	2	BT
47	BM 382	Biomedical Image Processing Laboratory	0-0-3	2	BT
48	BM 383	Biomedical Signal Processing Laboratory – I	0-0-3	2	BT
49	BM 384	Biomedical Instrumentation Laboratory	0-0-3	2	BT

50	BM 385	Medical Equipment Design Laboratory	0-0-3	2	#
51	BM 386	Experimental Biomechanics Laboratory	0-0-3	2	#
52	BM 387	Biomedical Signal Processing Laboratory - II	0-0-3	2	#
53	BM 391	Special Topics in Biotechnology & Medical Engg.–I		3/4	#
54	BM 392	Special Topics in Biotechnology & Medical Engg.–II		3/4	#
55	BM 393	Special Laboratory in Biotechnology & Medical Engg.–I	0-0-3	2	#
56	BM 394	Special Laboratory in Biotechnology & Medical Engg.–II	0-0-3	2	#
57	BM 395	Engineering Product Development Project – I	0-0-6	4	#
58	BM 396	Engineering Product Development Project – II	0-0-6	4	#
59	BM 401	Hospital Management	3-0-0	3	#
60	BM 402	Health Informatics	3-0-0	3	#
61	BM 403	Hospital Engineering and Information system	3-0-0	3	#
62	BM 405	Telemedicine	3-0-0	3	#
63	BM 411	Medical Embedded system	3-0-0	3	#
64	BM 413	Medical Imaging	3-0-0	3	#
65	BM 421	Tissue engineering	3-0-0	3	BT
66	BM 422	Computer Application in Tissue Engineering	3-0-0	3	#
67	BM 423	Nanotechnology in Tissue Engineering	3-0-0	3	#
68	BM 424	Artificial Organs and Rehabilitation Engineering	3-0-0	3	#
69	BM 425	Biomaterials in Tissue Engineering	3-0-0	3	#
70	BM 427	BioComposites	3-0-0	3	#
71	BM 428	Nanotechnology in Biomedical Engineering	3-0-0	3	#
72	BM 431	Physiological system modeling	3-0-0	3	#
73	BM 432	Biomicrofluidics	3-0-0	3	#
74	BM 433	Biotransport	3-0-0	3	#
75	BM 441	Protein Engineering	3-0-0	3	BM
76	BM 442	Cancer Biology	3-0-0	3	#
77	BM 444	Structural Biology	3-0-0	3	#
78	BM 452	Fermentation Technology	3-0-0	3	#
79	BM 463	Food Technology	3-0-0	3	#
80	BM 465	Biological waste treatment	3-0-0	3	#
81	BM 483	Computational Biomechanics Laboratory	0-0-3	2	BT
82	BM 484	Structural Biology Laboratory	0-0-3	2	BM
83	BM 252	Bioenergetics & Metabolism	3-0-0	3	BM

Note: *# for both BM & BT Engineering Curriculum*

LIST OF PROFESSIONAL ELECTIVES FROM OTHER DEPARTMENTS

Sl. No	Sub.Code	Subject	L-T-P	Credit
1	CH 224	Polymer Science and Technology	3-0-0	3
2	CH 311	Heat Transfer Operations	3-1-0	4
3	CH 315	Mass Transfer Operations	3-1-0	4
4	CH 322	Environmental Biotechnology	3-0-0	3

5	CH 425	Environmental Engineering	3-0-0	3
6	CR 325	Computational Materials Science	3-0-0	3
7	CR 433	Sensor Technology	3-0-0	3
8	CR 435	Functional Materials & Devices	3-0-0	3
9	CR 415	Bio-ceramics	3-0-0	3
11	CS 222	Data Base Management	3-0-0	3
12	CS 314	Simulation and Modeling	3-0-0	3
13	CS 341	Microprocessor and Micro-controllers	3-1-0	4
14	CS 373	Microprocessor Laboratory	0-0-3	2
15	CS 421	Computer Networks	3-0-0	3
16	CS 474	Image Processing Laboratory	0-0-3	2
17	CS 477	Soft Computing Laboratory	0-0-3	2
18	CS 638	Pattern Recognition	3-1-0	4
19	CY 303	Introduction to Nano-biotechnology	3-0-0	3
20	CY 517	Chemistry of Natural Products.	3-1-0	4
21	CY 602	Industrial Waste Management	3-1-0	4
22	EC 322	Embedded Systems	3-0-0	3
23	EC 331	Control System Engineering	3-1-0	4
26	EC 421	Digital VLSI Design	3-1-0	4
27	EC 423	HDL and High Level VLSI	3-1-0	4
29	EC 442	Advanced Techniques in Digital Signal Processing	3-1-0	4
30	EC 444	Soft Computing	3-1-0	4
31	EC 446	Adaptive Signal Processing	3-1-0	4
34	EE 336	Advanced Instrumentation	3-0-0	3
35	EE 356	Digital Signal Processing	3-0-0	3
36	EE 426	Fuzzy Modeling & Control	3-0-0	3
37	EE 427	Soft computing	3-0-0	3
38	EE 445	Data communication and Networks	3-0-0	3
39	EE 456	Robotics and Computer Vision	3-0-0	3
40	MA 524	Statistical Methods	3-1-0	4
41	MA 553	Optimization Techniques	3-1-0	4
42	ME 416	Robotics	3-0-0	3
43	ME 434	Computer Graphics for CAD/CAM	3-0-0	3
44	MM 359	Engineering Polymers and Composites	3-1-0	4
45	MM 449	Nano Structure of Materials	3-0-0	3
46	MN 436	Environmental Pollution and Control in Mines	3-1-0	4
47	PH 555	Physics of Material Synthesis and Characterization	3-1-0	4
48	PH 640	Physics of Macromolecules	3-1-0	4

LIST OF OPEN ELECTIVES

(Normally not offered to student of Biotechnology and Biomedical Engineering)

Sub.Code	Subjects	L-T-P	Credits	Non Eligible Branches
BM 317	Biomedical Engineering	3-0-0	3	-
BM 318	Medical Instrumentation	3-0-0	3	-
BM 415	Electronic devices for Rehabilitation Engineering	3-0-0	3	-
BM 429	Materials in medical science	3-0-0	3	-
BM 443	Introduction to Biotechnology	3-0-0	3	-

SUMMARY OF COURSES (B.Tech.)

Sub Discipline: Miscellaneous Topics

BM 201	Anatomy and Physiology	3-0-0	3
BM 202	Clinical Science	3-1-0	4
BM 203	Clinical Biochemistry	3-0-0	3
BM 205	Clinical Microbiology	3-0-0	3
BM 401	Hospital Management	3-0-0	3
BM 402	Health Informatics	3-0-0	3
BM 403	Hospital Engineering and Information system	3-0-0	3
BM 405	Telemedicine	3-0-0	3

Sub Discipline: Medical Electronics and Instrumentation

BM 311	Medical Signal and Signal Processing	3-1-0	4
BM 312	Biomedical Instrumentation	3-1-0	4
BM 313	Biological Control System	3-0-0	3
BM 314	Biomedical Image Processing	3-1-0	4
BM 315	Laser & Fiber Optics in Medicine	3-0-0	3
BM 316	Biosensors and Biotransducers	3-0-0	3
BM 317	Biomedical Engineering	3-0-0	3
BM 318	Medical Instrumentation	3-0-0	3
BM 411	Medical Embedded system	3-0-0	3
BM 413	Medical Imaging	3-0-0	3
BM 415	Electronic devices for Rehabilitation Engineering	3-0-0	3

Sub Discipline: Tissue Engineering and Biomaterials

BM 321	Biomaterials	3-1-0	4
BM 322	Biopolymers	3-0-0	3
BM 324	Surface Engineering of Biomaterials	3-0-0	3
BM 421	Tissue engineering	3-0-0	3
BM 422	Computer Application in Tissue Engineering	3-0-0	3
BM 423	Nanotechnology in Tissue Engineering	3-0-0	3
BM 424	Artificial Organs and Rehabilitation Engineering	3-0-0	3
BM 425	Biomaterials in Tissue Engineering	3-0-0	3

BM 427	BioComposites	3-0-0	3
BM 428	Nanotechnology in Biomedical Engineering	3-0-0	3
BM 429	Materials in medical science	3-0-0	3

Sub Discipline: Bio-transport and Biomechanics

BM 232	Biofluid Mechanics	3-1-0	4
BM 234	Biothermodynamics	3-0-0	3
BM 331	Bioheat and Mass Transfer	3-1-0	4
BM 332	Biomechanics	3-0-0	3
BM 431	Physiological system modeling	3-0-0	3
BM 432	Biomicrofluidics	3-0-0	3
BM 433	Biotransport	3-0-0	3

Sub Discipline: Cell and Molecular Engineering

BM 242	Immunology	3-0-0	3
BM 244	Cell and Molecular Biology	3-0-0	3
BM 341	Genetic Engineering	3-1-0	4
BM 342	Applied Cell Biology	3-0-0	3
BM 343	Bioinformatics	3-0-0	3
BM 345	Animal Tissue Culture	3-0-0	3
BM 441	Protein Engineering	3-0-0	3
BM 442	Cancer Biology	3-0-0	3
BM 443	Introduction to Biotechnology	3-0-0	3
BM 444	Structural Biology	3-0-0	3

Sub Discipline:Bioprocess Engineering

BM 252	Bioenergetics & Metabolism	3-0-0	3
BM 254	Bioprocess Calculation	3-0-0	3
BM 256	Enzymology	3-0-0	3
BM 352	Biochemical Engineering	3-1-0	4
BM 353	Pharmaceutical Technology	3-0-0	3
BM 354	Bioseparation	3-1-0	4
BM 356	Bioinstrumentation and Process Control	3-1-0	4
BM 358	Bioreactor Analysis & Design	3-0-0	3
BM 452	Fermentation Technology	3-0-0	3

Sub Discipline: Agricultural and Environmental Biotechnology

BM 361	Agricultural Biotechnology	3-0-0	3
BM 362	Plant Tissue Culture	3-0-0	3
BM 463	Food Technology	3-0-0	3
BM 465	Biological waste treatment	3-0-0	3

Sub Discipline: Laboratory Courses

BM 271	Anatomy and Physiology Laboratory	0-0-3	2
BM 272	Biofluid Mechanics Laboratory	0-0-3	2

BM 273	Clinical Biochemistry Laboratory	0-0-3	2
BM 274	Analytical Biotechnology Laboratory	0-0-3	2
BM 275	Clinical Microbiology Laboratory	0-0-3	2
BM 282	Clinical Science Laboratory	0-0-3	2
BM 370	Bioinformatics Laboratory	0-0-3	2
BM 371	Cell and Molecular Engineering Laboratory	0-0-3	2
BM 372	Bioseparation Laboratory	0-0-3	2
BM 373	Environmental Biotechnology Laboratory	0-0-3	2
BM 374	Biochemical Engineering Laboratory	0-0-3	2
BM 375	Bioheat and Mass transfer Laboratory	0-0-3	2
BM 376	Bioprocess Instrumentation Laboratory	0-0-3	2
BM 378	Animal Cell Culture and Immunotechnology Laboratory	0-0-3	2
BM 381	Biomaterial Laboratory	0-0-3	2
BM 382	Biomedical Image Processing Laboratory	0-0-3	2
BM 383	Biomedical Signal Processing Laboratory – I	0-0-3	2
BM 384	Biomedical Instrumentation Laboratory	0-0-3	2
BM 385	Medical Equipment Design Laboratory	0-0-3	2
BM 386	Experimental Biomechanics Laboratory	0-0-3	2
BM 387	Biomedical Signal Processing Laboratory – II	0-0-3	2
BM 471	Bioprocess Design Laboratory	0-0-3	2
BM 472	Biomicrofluidics Laboratory	0-0-3	2
BM 473	Food Technology Laboratory	0-0-3	2
BM 481	Tissue Engineering Laboratory	0-0-3	2
BM 482	Computer Aided Tissue Engineering Laboratory	0-0-3	2
BM 483	Computational Biomechanics Laboratory	0-0-3	2
BM 484	Structural Biology Laboratory	0-0-3	2

Sub Discipline: Project, Seminar and Special Courses

BM 391	Special Topics in Biotechnology & Medical Engg.–I		3/4
BM 392	Special Topics in Biotechnology & Medical Engg.–II		3/4
BM 393	Special Laboratory in Biotechnology & Medical Engg.–I	0-0-3	2
BM 394	Special Laboratory in Biotechnology & Medical Engg.–II	0-0-3	2
BM 395	Engineering Product Development Project – I	0-0-6	4
BM 396	Engineering Product Development Project – II	0-0-6	4
BM 491	Research Project–I	0-0-6	4
BM 492	Research Project–II	0-0-9	6
BM 493	Seminar and Technical Writing–I	0-0-3	2
BM 494	Seminar and Technical Writing–II	0-0-3	2
BM 495	Short term Industrial / Research Experience	0-0-3	2
BM 496	Comprehensive Viva Voce	0-0-0	2

DEPARTMENT OF CIVIL ENGINEERING

Curriculum of B. Tech (Civil Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subject		L-T-P	Credits
1	MA 101	Mathematics – I		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 Engineering	OR	3-1-0	4
	EC 100	Basic Electronics Engineering			
5	CE 100	Engineering Mechanics	OR	3-1-0	4
	CE 130	Environment 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	Subject		L-T-P	Credits
1	MA 102	Mathematics – II		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithm		3-1-0	4
4	EC 100	Basic Electronics Engineering	OR	3-1-0	4
	EE 100	Basic Electrical Engineering			
5	CE 130	Environment 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 – II		0-0-3	2
		TOTAL			**30**

THIRD SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	MA 201	Mathematics – III	3-1-0	4
2	CE 201	Civil Engineering Materials and Construction	3-0-0	3
3	CE 203	Mechanics of Solids	3-0-0	3
4		Professional Elective – I	3-1-0	4

5		HS & Open Elective	3-0-0	3
6	EE 270	Basic Electrical Engineering Laboratory OR	0-0-3	2
	EC 270	Basic Electronics Laboratory		
7	MA 270	Numerical Methods Laboratory OR	0-0-3	2
	HS 270	Language Laboratory		
8	CE 271	Building Drawing Practice	0-0-3	2
9	CE 273	Mechanics of Solids Laboratory	0-0-3	2
		TOTAL		**25**

FOURTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	MA 202	Mathematics – IV	3-1-0	4
2	CE 202	Surveying	3-0-0	3
3	CE 212	Structural Analysis	3-0-0	3
4	CE 252	Fluid Mechanics	3-1-0	4
5		HS & Open Elective – II	3-0-0	3
6	EE 270	Electrical Engineering Laboratory – I OR	0-0-3	2
	EC 270	Basic Electronics Laboratory		
7	MA 270	Numerical Methods Laboratory OR	0-0-3	2
	HS 270	Language Laboratory		
8	CE 272	Highway Engineering Laboratory	0-0-3	2
9	CE 274	Surveying Field Work	0-0-3	2
		TOTAL		**25**

FIFTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CE 311	Structural Design	3-0-0	3
2	CE 321	Mechanics of Soil	3-0-0	3
3	CE 331	Environment Engineering	3-0-0	3
4		Professional Elective – II	3-1-0	4
5		HS & Open Elective – III	3-0-0	3
6	CE 371	Geotechnical Engineering Laboratory	0-0-3	2
7	CE 373	Advanced Surveying Field Work	0-0-3	2
8	CE 375	Structural Engineering Design Practice	0-0-3	2
9	CE 377	Fluid Mechanics & Hydraulic Machines Laboratory	0-0-3	2
		TOTAL		**24**

SIXTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CE 312	Design of Steel Structures	3-0-0	3
2	CE 322	Geotechnical Engineering	3-0-0	3
3	CE 342	Transportation Engineering	3-0-0	3
4		Professional Elective – III	3-1-0	4

5		HS & Open Elective – IV	3-0-0	3
6	CE 372	Steel Structures Design Practice	0-0-3	2
7	CE 374	Transportation Engineering Design Practice	0-0-3	2
8	CE 376	Environmental Engineering Design Practice	0-0-3	2
9	CE 378	Environmental Engineering Laboratory	0-0-3	2
		TOTAL		**24**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CE 401	Estimation & Construction Management	3-1-0	4
2		Professional Elective – IV	3-0-0	3
3		Professional Elective – V	3-0-0	3
4		Professional Elective – VI	3-0-0	3
5		HS & Open Elective – V	3-0-0	3
6	CE 471	Computer Aided Design Practice	0-0-3	2
7	CE 473	Geotechnical Engineering Design Practice	0-0-3	2
8	CE 491	Research Project – I	0-0-6	4
9	CE 493	Seminar & Technical Writing – I	0-0-3	2
10	CE 495	Short term Industrial/Research Experience	0-0-3	2
		TOTAL		**28**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CE 452	Water Resources Engineering	3-0-0	3
2		Professional Elective – VII	3-0-0	3
3		Professional Elective – VIII	3-0-0	3
4		HS & Open Elective – VI	3-0-0	3
5	CE 472	Structural Engineering Laboratory	0-0-3	2
6	CE 474	Water Resources Engineering Design Practice	0-0-3	2
7	CE 492	Research Project – II	0-0-9	6
8	CE 494	Seminar & Technical Writing – II	0-0-3	2
9	CE 496	Comprehensive Viva-Voce	0-0-0	2
		TOTAL		**26**

Curriculum of M.Tech Dual Degree (Specialization: Geotechnical Engineering)

[1st - 6th Semester curricula are common with B.Tech. Civil Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	CE 621	Advanced Soil Mechanics	3-1-0	4
2	CE 625	Soil Exploration and Analysis of Foundations	3-1-0	4
3		Professional Electives – IV (B.Tech.)	3-1-0	4
4		Professional Electives – V (B.Tech.)	3-1-0	4
5		Professional Electives – VI (B.Tech.)	3-1-0	4

6	CE 673	Geotechnical Engineering Laboratory	0-0-3	2
7	CE 681	Computational Laboratory	0-0-3	2
8	CE 491	Research Project – I	0-0-3	2
9	CE 685	Seminar & Technical Writing - I	0-0-3	2
10	CE 691	Short Term Industrial/Research Experience	0-0-0	2
		TOTAL	**15-5-12**	**30**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	CE 620	Ground Improvement Techniques	3-1-0	4
2	CE 622	Stability Analysis of Slopes, Dams and Embankments	3-1-0	4
3		Professional Electives – VII (B.Tech.)	3-0-0	3
4		Professional Electives – VIII (B.Tech.)	3-0-0	3
5		Professional Electives – IX (B.Tech.)	3-0-0	3
6	CE 672	Geotechnical Engineering Design Practice	0-0-3	2
7	CE 682	Computer Aided Foundation Engineering Design	0-0-3	2
8	CE 492	Research Project – II	0-0-3	2
9	CE 686	Seminar & Technical Writing – II	0-0-3	2
		TOTAL	**15-2-12**	**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Electives – IX (M.Tech.)	3-1-0	4
2		Professional Electives – X (M.Tech.)	3-1-0	4
3		Professional Electives – XI (M.Tech.)	3-1-0	4
4	CE 687	Seminar and Technical Writing – III	0-0-3	2
5	CE 693	Research Project – III(Summer)	0-0-0	10
6	CE 694	Research Project – IV	0-0-0	10
		TOTAL	**9-3-3**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	CE 688	Seminar and Technical Writing – IV	0-0-3	2
2	CE 692	Comprehensive Viva Voce	0-0-0	4
3	CE 695	Research Project – V	0-0-30	20
		TOTAL	**0-0-33**	**26**

Curriculum of M. Tech Dual Degree (Specialization: Structural Engineering)

[1st - 6th Semester curricula are common with B.Tech. Civil Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CE 611	Advanced Structural Analysis	3-1-0	4
2	CE 613	Analysis & Design of Plates and Shells	3-1-0	4

3		Professional Elective – III (B.Tech.)	3-0-0	3
4		Professional Elective – IV (B.Tech.)	3-0-0	3
5		Professional Elective – V (B.Tech.)	3-0-0	3
6	CE 491	Research Project – I	0-0-3	2
7	CE 493	Seminar and Technical Writing – I	0-0-3	2
8	CE 671	Structural Engineering Laboratory	0-0-3	2
9	CE 681	Computational Laboratory – I	0-0-3	2
10	CE 691	Short Term Industrial/Research Experience	0-0-0	2
TOTAL			**15-2-12**	**27**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CE 604	Finite Element Method	3-1-0	4
2	CE 612	Stability of Structures	3-1-0	4
3		Professional Elective – VI (B.Tech.)	3-0-0	3
4		Professional Elective – VII (B.Tech.)	3-0-0	3
5		Professional Elective – VIII (B.Tech.)	3-0-0	3
6	CE 492	Research Project – II	0-0-3	2
7	CE 494	Seminar and Technical Writing – II	0-0-3	2
8	CE 670	Structural Engineering Design Practice	0-0-3	2
9	CE 680	Computational Laboratory – II	0-0-3	2
TOTAL			**15-2-12**	**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1		Professional Elective – I (M.Tech.)	3-1-0	4
2		Professional Elective – II (M.Tech.)	3-1-0	4
3		Professional Elective – III (M.Tech.)	3-1-0	4
4	CE 687	Seminar and Technical Writing – III	0-0-3	2
5	CE 693	Research Project – III(Summer)	0-0-0	10
6	CE 694	Research Project – IV	0-0-0	10
TOTAL			**9-3-3**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CE 688	Seminar and Technical Writing – IV	0-0-3	2
2	CE 692	Comprehensive Viva – Voce	0-0-0	4
3	CE 695	Research Project – V	0-0-30	20
TOTAL			**0-0-33**	**26**

Curriculum of M. Tech Dual Degree (Specialization: Transportation Engineering)

[1st - 6th Semester curricula are common with B.Tech. Civil Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	CE 641	Transportation Systems Planning	3-1-0	4
2	CE 643	Highway and Airport Pavement Materials	3-1-0	4
3		Professional Elective – IV (B.Tech.)	3-1-0	4
4		Professional Elective – V (B.Tech.)	3-1-0	4
5		Professional Elective – VII (B.Tech.)	3-1-0	4
6	CE 677	Transportation Engineering Laboratory	0-0-3	2
7	CE 681	Computational Laboratory	0-0-3	2
8	CE 491	Research Project – I	0-0-3	2
9	CE 685	Seminar and Technical Writing – I	0-0-3	2
10	CE 691	Short Term Industrial/Research Experience	0-0-0	2
		TOTAL	**15-5-12**	**30**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	CE 640	Analysis and Structural Design and Pavements	3-1-0	4
2	CE 642	Traffic Engineering & Traffic Flow	3-1-0	4
3		Professional Elective – VII (B.Tech.)	3-0-0	3
4		Professional Elective – VIII (B.Tech.)	3-0-0	3
5		Professional Elective – IX (B.Tech.)	3-0-0	3
6	CE 674	Transportation Engineering Design Practice	0-0-3	2
7	CE 676	Traffic & Transportation Engineering Laboratory	0-0-3	2
8	CE 492	Research Project – II	0-0-3	2
9	CE 686	Seminar and Technical Writing – II	0-0-3	2
		TOTAL	**15-2-12**	**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Elective – IX (M.Tech.)	3-1-0	4
2		Professional Elective – X (M.Tech.)	3-1-0	4
3		Professional Elective – XI (M.Tech.)	3-1-0	4
4	CE 687	Seminar and Technical Writing – III	0-0-3	2
5	CE 693	Research Project – III(Summer)	0-0-0	10
6	CE 694	Research Project – IV	0-0-0	10
		TOTAL	**9-3-3**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	CE 688	Seminar and Technical Writing – IV	0-0-3	2
2	CE 692	Comprehensive Viva Voce	0-0-0	4

3	CE 695	Research Project – V	0-0-30	20
TOTAL			**0-0-33**	**26**

Curriculum of M. Tech Dual Degree (Specialization: Water Resources Engineering)

[1st - 6th Semester curricula are common with B.Tech. Civil Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CE 609	Estimation & Construction Management	3-1-0	4
2	CE 637	Irrigation Engineering	3-1-0	4
3		Professional Elective – IV (B. Tech.)	3-1-0	4
4		Professional Elective – V (B. Tech.)	3-1-0	4
5		Professional Elective – VI (B. Tech.)	3-1-0	4
6	CE 471	Computer Aided Design Practice	0-0-3	2
7	CE 491	Research Project – I	0-0-3	2
8	CE 493	Seminar & Technical Writing – I	0-0-3	2
9	CE 691	Short Term Industrial/Research Experience	0-0-0	2
TOTAL			**15-5-9**	**28**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CE 658	Water Resources Engineering	3-0-0	3
2	CE 652	Open Channel Flow	3-1-0	4
3		Professional Elective – VII (B. Tech.)	3-1-0	4
4		Professional Elective – VIII (B. Tech.)	3-1-0	4
5		Professional Elective – IX (B. Tech.)	3-1-0	4
6	CE 474	Water resources Engineering Design Practice	0-0-3	2
7	CE 492	Research Project – II	0-0-3	2
8	CE 686	Seminar & Technical Writing – II	0-0-3	2
TOTAL				**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Elective – X (I of M. Tech.)	3-1-0	4
2		Professional Elective – XI (II of M. Tech.)	3-1-0	4
3		Professional Elective – XII (III of M. Tech)	3-1-0	4
4	CE 687	Seminar & Technical Writing – III	0-0-3	2
5	CE 693	Research Project – III(Summer)	0-0-0	10
6	CE 694	Research Project – IV	0-0-0	10
TOTAL				**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CE 688	Seminar & Technical Writing – IV	0-0-3	2
2	CE 692	Comprehensive Viva Voce	0-0-0	4
3	CE 695	Research Project – V	0-0-30	20
		TOTAL		**26**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subjects	L-T-P	Credits	Offerred to
1	CE 205	Architecture & Town Planning	3-1-0	4	#
2	CE 207	Cost Effective Housing	3-1-0	4	#
3	CE 209	Concrete Technology	3-1-0	4	#
4	CE 301	Advanced Surveying	3-1-0	4	#
5	CE 313	Advanced structural analysis	3-1-0	4	#
6	CE 314	Structural Dynamics	3-1-0	4	#
7	CE 316	Advanced Mechanics of Solids	3-1-0	4	#
8	CE 318	Finite Element Method	3-1-0	4	#
9	CE 333	Environmental Impact Assessment	3-1-0	4	#
10	CE 334	Air Quality Management	3-1-0	4	#
11	CE 336	Advanced Environmental Engineering	3-1-0	4	#
12	CE 351	Hydraulics and Hydraulic Machines	3-1-0	4	#
13	CE 352	Advanced Fluid Mechanics	3-1-0	4	#
14	CE 391	Special Topic in Civil Engineering – I		3/4	#
15	CE 392	Special Topic in Civil Engineering – II		3/4	#
16	CE 393	Special Laboratory in Civil Engineering - I	0-0-3	2	#
17	CE 394	Special Laboratory in Civil Engineering - II	0-0-3	2	#
18	CE 395	Engineering Product Development Project - I	0-0-6	4	#
19	CE 396	Engineering Product Development Project - II	0-0-6	4	#
20	CE 405	Disaster Management	3-0-0	3	#
21	CE 407	Optimization Methods and Its Applications in Civil Engineering	3-0-0	3	#
22	CE 411	Plate and Shell Structures	3-0-0	3	#
23	CE 412	Pre-stressed Concrete	3-0-0	3	#
24	CE 413	Advanced Design of Reinforced Concrete Structures	3-0-0	3	#
25	CE 415	Earthquake and Wind Resistant Design of Structures	3-0-0	3	#
26	CE 418	Probability and Reliability Methods in Civil Engineering	3-1-0	4	#
27	CE 421	Ground Improvement Techniques	3-0-0	3	#
28	CE 423	Advanced Foundation Engineering	3-0-0	3	#

29	CE 424	Earthquake Geotechnical Engineering	3-0-0	3	#
30	CE 425	Environmental Geotechnics	3-0-0	3	#
31	CE 426	Soil Structure Interaction	3-0-0	3	#
32	CE 428	Soil Dynamics and Industrial Foundations	3-0-0	3	#
33	CE 432	Environmental Biotechnology	3-0-0	3	#
34	CE 441	Advanced Transportation Engineering	3-0-0	3	#
35	CE 442	Traffic Engineering & Transportation Planning	3-0-0	3	#
36	CE 443	Pavement Design	3-0-0	3	#
37	CE 444	Pavement Materials	3-0-0	3	#
38	CE 445	Design of Airports and Hill Roads	3-0-0	3	#
39	CE 451	Irrigation Engineering	3-0-0	3	#
40	CE 453	Computational Fluid Dynamics	3-0-0	3	#
41	CE 454	Ground Water Hydrology	3-0-0	3	#
42	CE 455	Open Channel Flow	3-0-0	3	#
43	CE 456	Water Resources Planning and Management	3-0-0	3	#
44	CE 601	Material Technology	3-1-0	4	$
45	CE 603	Applied Elasticity and Plasicity	3-1-0	4	$
46	CE 615	Advanced Steel Design	3-1-0	4	$
47	CE 617	Bridge Engineering	3-1-0	4	$
48	CE 619	Composite Structure	3-1-0	4	$
49	CE 626	Rock Mechanics	3-1-0	4	$
50	CE 627	Dynamics of Soils and Foundations	3-1-0	4	$
51	CE 628	Earth Retaining Structures	3-1-0	4	$
52	CE 629	Earthquake Geotechnical Engineering	3-1-0	4	$
53	CE 635	Environmental Impact & Risk Assessment	3-1-0	4	$
54	CE 638	Environmental Legislation & Policy	3-1-0	4	$
55	CE 645	Geometric Design of Highways	3-1-0	4	$
56	CE 646	Evaluation and Strengthening of Pavements	3-1-0	4	$
57	CE 647	Transportation & Environment	3-1-0	4	$
58	CE 648	Transportation Systems, Analysis & Modelling	3-1-0	4	$
59	CE 649	Advanced Railway Engineering	3-1-0	4	$
60	CE 660	High Rise Structures	3-1-0	4	$
6	CE 661	Strength & Deformation Behaviour of Soils	3-1-0	4	$
62	CE 662	Environmental Geotechniques	3-1-0	4	$
63	CE 663	Mass Transit Systems	3-1-0	4	$
64	CE 666	Analytical and Numerical Methods in Geotechnical Engg.	3-1-0	4	$
65	CE 667	Soil Elasticity and Plasticity	3-1-0	4	$

Note: # (B.Tech. and all dual degree courses), $ (only for dual degree courses)

PROFESSIONAL ELECTIVES FROM OTHER DEPARTMENTS

Sl. No	Sub. Code.	Subject	L-T-P	Credits
1	BM 352	Biochemical Engineering	3-0-0	3
2	CS 437	Soft Computing	3-0-0	3
3	EE 356	Digital Signal Processing	3-0-0	3
4	MM 357	Corrosion & Degradation of Materials & Prevention	3-1-0	4
5	MM 359	Engineering Polymers & Composites	3-1-0	4
6	MN 207	Mining Geology	3-0-0	3
7	MN 208	Geostatistics	3-0-0	3
8	MN 322	Geomechanics	3-1-0	4

LIST OF OPEN ELECTIVES

(Normally not offered to students of Civil Engineering)

Sl. No	Sub. Code.	Subject	L-T-P	Credits	Non Eligible Branches
1	CE 204	Elements of Architecture & Town Planning	3-0-0	3	-
2	CE 214	Theory of Elasticity	3-0-0	3	ME, MN
3	CE 261	Elements of Civil Engineering	3-0-0	3	-
4	CE 302	Disaster Management	3-0-0	3	-
5	CE 303	Remote Sensing and Geographical Information System	3-0-0	3	-
8	CE 341	Basic Transportation Engineering	3-0-0	3	-
6	CE 403	Optimization Methods in Engineering	3-0-0	3	-
9	CE 404	Quality Management	3-0-0	3	-
7	CE 436	Environmental Management in Industry	3-0-0	3	-

SUMMARY OF COURSES

Sub Discipline:	Non Specific Subjects		
CE 100	Engineering Mechanics	3-1-0	4
CE 201	Civil Engineering Materials and Construction	3-0-0	3
CE 202	Surveying	3-0-0	3
CE 203	Mechanics of Solids	3-0-0	3
CE 204	Elements of Architecture & Town Planning	3-0-0	3
CE 205	Architecture & Town Planning	3-1-0	4
CE 207	Cost Effective Housing	3-1-0	4
CE 209	Concrete Technology	3-1-0	4
CE 261	Elements of Civil Engineering	3-0-0	3
CE 301	Advanced Surveying	3-1-0	4
CE 302	Disaster Management	3-0-0	3
CE 303	Remote Sensing and Geographical Information System	3-0-0	3
CE 305	Remote Sensing and Geographical Information System applications in Civil Engineering	3-1-0	4

CE 403	Optimization Methods in Engineering	3-0-0	3
CE 404	Quality Management	3-0-0	3
CE 405	Disaster Management	3-0-0	3
CE 407	Optimization Methods and Its Applications in Civil Engineering	3-0-0	3
CE 603	Applied Elasticity and Plasticity	3-1-0	3
CE 609	Estimation & Construction Management	3-1-0	4

Sub Discipline:	**Structural Engineering**		
CE 212	Structural Analysis	3-0-0	3
CE 214	Theory of Elasticity	3-0-0	3
CE 311	Structural Design	3-0-0	3
CE 312	Design of Steel Structures	3-0-0	3
CE 313	Advanced structural analysis	3-1-0	4
CE 314	Structural Dynamics	3-1-0	4
CE 316	Advanced Mechanics of Solids	3-1-0	4
CE 318	Finite Element Method	3-1-0	4
CE 411	Plate and Shell Structures	3-0-0	3
CE 412	Pre-stressed Concrete	3-0-0	3
CE 413	Advanced Design of Reinforced Concrete Structures	3-0-0	3
CE 415	Earthquake and Wind Resistant Design of Structures	3-0-0	3
CE 418	Probability and Reliability Methods in Civil Engineering		
CE 601	Material Technology	3-1-0	4
CE 604	Finite Element Method	3-1-0	4
CE 611	Advanced Structural Analysis	3-1-0	4
CE 612	Stability of Structures	3-1-0	4
CE 613	Analysis & Design of Plate and Shells	3-1-0	4
CE 615	Advanced Steel Design	3-1-0	4
CE 617	Bridge Engineering	3-1-0	4
CE 619	Composite Structure	3-1-0	4
CE 660	High Rise Structures	3-1-0	4

Sub Discipline:	**Geotechnical Engineering**		
CE 321	Mechanics of Soil	3-0-0	3
CE 322	Geotechnical Engineering	3-0-0	3
CE 421	Ground Improvement Techniques	3-0-0	3
CE 423	Advanced Foundation Engineering	3-0-0	3
CE 424	Earthquake Geotechnical Engineering	3-0-0	3
CE 425	Environmental Geotechnics	3-0-0	3
CE 426	Soil Structure Interaction	3-0-0	3
CE 428	Soil Dynamics and Industrial Foundations	3-0-0	3
CE 620	Ground Improvement Techniques	3-1-0	4
CE 621	Advanced Soil Mechanics	3-1-0	4

CE 622	Stability Analysis of Slopes, Dams and Embankments	3-1-0	4
CE 625	Soil Exploration and Analysis of Foundations	3-1-0	4
CE 626	Rock Mechanics	3-1-0	4
CE 627	Dynamics of Soils and Foundations	3-1-0	4
CE 628	Earth Retaining Structures	3-1-0	4
CE 629	Earthquake Geotechnical Engineering	3-1-0	4
CE 661	Strength & Deformation Behaviour of Soil	3-1-0	4
CE 662	Environmental Geotechnics	3-1-0	4
CE 666	Analytical and Numerical Methods in Geotechnical Engineering	3-1-0	4
CE 667	Soil Elasticity and Plasticity	3-1-0	4

Sub Discipline:	Environmental Engineering

CE 130	Environment and Safety Engineering	3-1-0	4
CE 331	Environment Engineering	3-0-0	3
CE 333	Environmental Impact Assessment	3-1-0	4
CE 334	Air Quality Management	3-1-0	4
CE 336	Advanced Environmental Engineering	3-1-0	4
CE 432	Environmental Biotechnology	3-0-0	3
CE 436	Environmental Management in Industries	3-0-0	3
CE 635	Environmental Impact & Risk Assessment	3-1-0	4
CE 638	Environmental Legislation & Policy	3-1-0	4

Sub Discipline:	Transportation Engineering

CE 341	Basic Transportation Engineering	3-0-0	3
CE 342	Transportation Engineering	3-0-0	3
CE 441	Advanced Transportation Engineering	3-0-0	3
CE 442	Traffic Engineering & Transportation Planning	3-0-0	3
CE 443	Pavement Design	3-0-0	3
CE 444	Pavement Materials	3-0-0	3
CE 445	Design of Airports and Hill Roads	3-0-0	3
CE 640	Analysis and Structural Design and Pavements	3-1-0	4
CE 641	Transportation Systems Planning	3-1-0	4
CE 642	Traffic Engineering & Traffic Flow	3-1-0	4
CE 643	Highway and Airport Pavement Materials	3-1-0	4
CE 645	Geometric Design of Highways	3-1-0	4
CE 646	Evaluation and Strengthening of Pavements	3-1-0	4
CE 647	Transportation & Environment	3-1-0	4
CE 648	TransportationSystems, Analysis & Modelling	3-1-0	4
CE 649	Advanced Railway Engineering	3-1-0	4

Sub Discipline:	Water Resource Engineering

CE 252	Fluid Mechanics	3-1-0	4

CE 351	Hydraulics and Hydraulic Machines	3-1-0	4
CE 352	Advanced Fluid Mechanics	3-1-0	4
CE 453	Computational Fluid Dynamics	3-0-0	3
CE 454	Ground Water Hydrology	3-0-0	3
CE 455	Open Channel Flow	3-0-0	3
CE 456	Water Resources Planning and Management	3-0-0	3
CE 637	Irrigation Engineering	3-0-0	3
CE 652	Open Channel Flow	3-1-0	4
CE 658	Water Resources Engineering	3-0-0	3
CE 660	High Rise Structures	3-1-0	4
CE 661	Strength & Deformation Behaviour of Soils	3-1-0	4
CE 662	Environmental Geotechniques	3-1-0	4
CE 663	Mass Transit Systems	3-1-0	4

Sub Discipline:	**Laboratory Courses**		
CE 171	Engineering Drawing	0-0-3	2
CE 271	Building Drawing Practice	0-0-3	2
CE 272	Highway Engineering Laboratory	0-0-3	2
CE 273	Mechanics of Solids Laboratory	0-0-3	2
CE 274	Surveying Field Work	0-0-3	2
CE 371	Geotechnical Engineering Laboratory	0-0-3	2
CE 372	Steel Structures Design Practice	0-0-3	2
CE 373	Advanced Surveying Field Work	0-0-3	2
CE 374	Transportation Engineering Design Practice	0-0-3	2
CE 375	Structural Engineering Design Practice	0-0-3	2
CE 376	Environment Engineering Design Practice	0-0-3	2
CE 377	Fluid Mechanics & Hydraulic Machines Lab.	0-0-3	2
CE 378	Environment Engineering Laboratory	0-0-3	2
CE 471	Computer Aided Design Practice	0-0-3	2
CE 472	Structural Engineering Laboratory	0-0-3	2
CE 473	Geotechnical Engineering Design Practice	0-0-3	2
CE 474	Water Resources Engineering Design Practice	0-0-3	2
CE 670	Structural Engineering Design Practice	0-0-3	2
CE 671	Structural Engineering Laboratory	0-0-3	2
CE 672	Geotechnical Engineering Design Practice	0-0-3	2
CE 673	Geotechnical Engineering Laboratory	0-0-3	2
CE 674	Transportation Engineering Design Practice	0-0-3	2
CE 676	Traffic & Transportation Engineering Laboratory	0-0-3	2
CE 677	Transportation Engineering Laboratory	0-0-3	2

Sub Discipline:	**Project, Seminar and Special Courses**		
CE 391	Special Topic in Civil Engineering – I		3/4
CE 392	Special Topic in Civil Engineering – II		3/4

CE 393	Special Laboratory in Civil Engineering – I	0-0-3	2
CE 394	Special Laboratory in Civil Engineering – II	0-0-3	2
CE 395	Engineering Product Development Project – I	0-0-6	4
CE 396	Engineering Product Development Project – II	0-0-6	4
CE 491	Research Project – I	0-0-6	4
CE 492	Research Project – II	0-0-9	6
CE 493	Seminar & Technical Writing – I	0-0-3	2
CE 494	Seminar & Technical Writing – II	0-0-3	2
CE 495	Short term Industrial/Research Experience	0-0-0	2
CE 496	Comprehensive Viva – Voce	0-0-0	2
CE 680	Computational Laboratory – II	0-0-3	2
CE 681	Computational Laboratory – I	0-0-3	2
CE 682	Computer Aided Foundation Engineering Design	0-0-3	2
CE 685	Seminar & Technical Writing - I	0-0-3	2
CE 686	Seminar & Technical Writing – II	0-0-3	2
CE 687	Seminar and Technical Writing – III	0-0-3	2
CE 688	Seminar and Technical Writing – IV	0-0-3	2
CE 691	Short Term Industrial/Research Experience	0-0-0	4
CE 692	Comprehensive Viva	0-0-0	4
CE 693	Research Project – III	0-0-15	10
CE 694	Research Project – IV	0-0-0	10
CE 695	Research Project – V	0-0-30	20

DEPARTMENT OF CHEMICAL ENGINEERING

Curriculum of B. Tech (Chemical Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Mathematics – I		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				**15-5-15**	**30**

SECOND SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T-P	Credits
1	MA 102	Mathematics – II		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithm		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 - II		0-0-3	2
TOTAL				**15-5-15**	**30**

THIRD SEMESTER

Sl. No	Sub.Code	Subjects	L-T- P	Credits
1	MA 201	Mathematics – III	3-1-0	4
2	CH 211	Processing and Handling of Materials	3-0-0	3
3	CH 223	Chemical Process Technology	3-0-0	3
4	CH 225	Chemical Process Calculations	3-1-0	4

5		HS & Open Elective – I		3-0-0	3
6	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
7	EE 270	Electrical Engineering Laboratory – I	OR	0-0-3	2
	EC 270	Basic Electronics Laboratory			
8	CH 271	Process Technology Laboratory		0-0-3	2
9	CH 273	Fuels and Combustion Laboratory		0-0-3	2
		TOTAL			**25**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 202	Mathematics – IV		3-1-0	4
2	CH 212	Fluid Dynamics		3-1-0	4
3	CH 220	Chemical Engg. Thermodynamics		3-1-0	4
4		Professional Elective – I			3/4
5		HS & Open Elective – II		3-0-0	3
6	EE 270	Electrical Engineering Laboratory – I	OR	0-0-3	2
	EC 270	Electronics Laboratory			
7	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
8	CH 270	Materials Handling Laboratory	OR	0-0-3	2
9	CH 272	Fluid Dynamics Fundamentals Laboratory		0-0-3	2
		TOTAL			**26/27**

FIFTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CH 311	Heat Transfer Operations	3-1-0	4
2	CH 315	Mass Transfer Operations	3-1-0	4
3	CH 337	Equipment Design (Mech. Aspects)	3-1-0	4
4		Professional Elective – II	3-0-0	3
5		HS & Open Elective – III	3-0-0	3
6	CH 371	Heat Transfer Fundamentals Laboratory	0-0-3	2
7	CH 373	Mass Transfer Fundamentals Laboratory	0-0-3	2
8	CH 375	Biotechnology Laboratory	0-0-3	2
9	CH 377	Fluid Dynamics Applications Laboratory	0-0-3	2
		TOTAL		**26**

SIXTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CH 312	Transport Phenomena	3-1-0	4
2	CH 334	Process Dynamics and Control	3-1-0	4
3		Professional Elective – III		3/4
4		Professional Elective – IV		3/4

5		HS & Open Elective – IV	3-0-0	3
6	CH 370	Computer Aided Design Laboratory – I	0-0-3	2
7	CH 372	Heat Transfer Design Laboratory	0-0-3	2
8	CH 374	Mass Transfer Design Laboratory	0-0-3	2
9	CH 376	Process Instrumentation Laboratory	0-0-3	2
TOTAL				**25/26**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CH 421	Reaction Kinetics and Catalysis	3-1-0	4
2		Professional Elective – V		3
3		Professional Elective – VI		3
4		HS & Open Elective – V	3-0-0	3
5	CH 471	Chemical Reaction Engg. Laboratory	0-0-3	2
6	CH 473	Computer Aided Design Laboratory – II	0-0-3	2
7	CH 475	Process Dynamics and Control Laboratory	0-0-3	2
8	CH 491	Research Project – I	0-0-6	4
9	CH 493	Seminar and Technical Writing – I	0-0-3	2
10	CH 495	Short term Industrial / Research Experience	0-0-3	2
TOTAL				**27**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CH 422	Simulation, Modeling and optimization of Chemical Process	3-1-0	4
2		Professional Elective – VII	3-0-0	3
3		Professional Elective – VIII	3-0-0	3
4		HS & Open Elective – VI	3-0-0	3
5	CH 470	Process Simulation Laboratory	0-0-3	2
6	CH 492	Research Project – II	0-0-9	6
7	CH 494	Seminar and Technical Writing – II	0-0-3	2
8	CH 496	Comprehensive Viva Voce	0-0-0	2
TOTAL				**25**

Curriculum of M. Tech Dual Degree (Specialization: Chemical Engineering)

[1st - 6th Semester curricula are common with B.Tech. Chemical Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CH 611	Advanced Fluid Dynamics	3-1-0	4
2	CH 613	Advanced Mass Transfer	3-1-0	4
3		Professional Elective – V (B.Tech.)	3-0-0	3
4		Professional Elective – VI (B.Tech.)	3-0-0	3
5		Professional Elective – VII (B.Tech.)	3-0-0	3

6	CH 671	Chemical Engineering Lab – I	0-0-3	2
7	CH 673	Chemical Engineering Lab – II	0-0-3	2
8	CH 491	Research Project – I	0-0-3	2
9	CH 493	Seminar & Technical Writing – I	0-0-3	2
10	CH 691	Short Term Industrial/Research Experience	0-0-0	2
		TOTAL	**15-2-12**	**27**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CH 638	Advanced Reaction Engineering & Reactor Design	3-1-0	4
2	CH 632	Advanced Process Control	3-1-0	4
3		Professional Elective – VIII (B.Tech.)	3-0-0	3
4		Professional Elective – IX (B.Tech.)	3-0-0	3
5		Professional Elective – X (B.Tech.)	3-0-0	3
6	CH 670	Chemical Engineering Lab – III	0-0-3	2
7	CH 672	Chemical Engineering Lab – IV	0-0-3	2
8	CH 492	Research Project – II	0-0-3	2
9	CH 494	Seminar and Technical Writing – II	0-0-3	2
		TOTAL	**15-2-12**	**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Elective – XI (M.Tech)	3-1-0	4
2		Professional Elective – XII (M.Tech)	3-1-0	4
3		Professional Elective – XIII (M.Tech)	3-1-0	4
4	CH 687	Seminar & Technical Writing – III	0-0-3	2
5	CH 693	Research Project – III(Summer)	0-0-0	10
6	CH 694	Research Project – IV	0-0-0	10
		TOTAL	**9-3-3**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CH 688	Seminar & Technical Writing – IV	0-0-3	2
2	CH 692	Comprehensive Viva Voce	0-0-0	4
3	CH 695	Research Project - V	0-0-30	20
		TOTAL	**0-0-33**	**26**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subject	L-T-P	Credits	Offered to
1.	CH 224	Polymer Science and Technology	3-0-0	3	#
2.	CH 226	Fuels and Combustion	3-0-0	3	#
3.	CH 227	Fertilizer Technology	3-0-0	3	#
4.	CH 312	Transport Phenomena	3-1-0	4	$

5.	CH 321	Fundamentals of Biochemical Engineering	3-0-0	3	#
6.	CH 322	Environmental Biotechnology	3-0-0	3	#
7.	CH 323	Energy Conservation and Renewable sources of Energy	3-0-0	3	#
8.	CH 324	Particulate Science and Technology	3-0-0	3	#
9.	CH 330	Petroleum Refinery Engineering and Petrochemicals	3-0-0	3	#
10.	CH 331	Process Instrumentation	3-0-0	3	#
11.	CH 335	Applied Statistics for Chemical Engineers	3-0-0	3	#
12.	CH 336	Chemical Engineering Mathematics	3-1-0	4	#
13.	CH 391	Special Topic in Chemical Engineering – I		3/4	#
14.	CH 392	Special Topic in Chemical Engineering – II		3/4	#
15.	CH 393	Special Laboratory in Chemical Engg – I	0-0-3	2	#
16.	CH 394	Special Laboratory in Chemical Engg – II	0-0-3	2	#
17.	CH 395	Engineering Product Development Project – I	0-0-6	4	#
18.	CH 396	Engineering Product Development Project – II	0-0-6	4	#
19.	CH 414	Nanotechnology in Catalysis	3-0-0	3	#
20.	CH 415	Fluidization Engineering	3-1-0	4	#
21.	CH 417	Modern Separation Processes in Chemical Engineering	3-0-0	3	#
22.	CH 419	Computational Fluid Dynamics	3-1-0	4	#
23.	CH 425	Environmental Engineering	3-0-0	3	#
24.	CH 426	Coal Processing Technology	3-0-0	3	#
25.	CH 427	Colloid and Interfacial Engineering	3-0-0	3	#
26.	CH 428	Disaster Management in Chemical Industries	3-0-0	3	#
27.	CH 432	Optimization Techniques in Process Design	3-0-0	3	#
28.	CH 434	Project Engineering	3-0-0	3	#
29.	CH 615	Advanced Heat Transfer	3-1-0	4	$
30.	CH 621	Bioenergy Engineering	3-1-0	4	$
31.	CH 623	Environmental Management System	3-1-0	4	$
32.	CH 625	Bioprocess Engineering	3-1-0	4	$
33.	CH 629	Interfacial Science and Engineering	3-1-0	4	$
34.	CH 631	Process Plant Simulation	3-1-0	4	$
35.	CH 681	Special Topics in Chemical Engineering – I		3/4	$

Note: *# (B.Tech. and all dual degree courses), $(only for dual degree courses)*

PROFESSIONAL ELECTIVES FROM OTHER DEPARTMENTS

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	BM 321	Biomaterials	3-1-0	4
2	BM 358	Bioreactor Analysis & Design	3-0-0	3
3	CE 318	Finite Element method	3-1-0	4
4	CR 244	Introduction to Engineering Materials	3-0-0	3
5	CR 335	Instrumental Characterization	3-1-0	4

6	CY 518	Polymer Chemistry	3-1-0	4
7	EE 427	Artificial Neural Network	3-0-0	3
8	ME 356	Turbo Machinery	3-0-0	3
9	MM 357	Corrosion & Degradation of Materials & Prevention	3-1-0	4

COURSES OFFERED AS OPEN ELECTIVES

(Normally not offered to students of Chemical Engineering)

Sl. No	Sub. Code	Subject	L-T- P	Credits	Non Eligible Branches
1	CH 228	Treatment of Industrial Effluents	3-0-0	3	-
2	CH 229	Basic Chemical Engineering	3-0-0	3	-
3	CH 329	Process Plant Safety	3-0-0	3	-
4	CH 338	Industrial Instrumentation and Process Control	3-0-0	3	EE,EC,EI CS, ME
5	CH 418	Recent Separation Technologies	3-0-0	3	-
6	CH 439	Non-Traditional Optimization Techniques	3-0-0	3	-

SUMMARY OF COURSES

Sub discipline: Transfer Operation

CH 211	Processing and Handling of Materials	3-0-0	3
CH 212	Fluid Dynamics	3-1-0	4
CH 311	Heat Transfer Operations	3-1-0	4
CH 312	Transport Phenomena	3-1-0	4
CH 315	Mass Transfer Operations	3-1-0	4
CH 323	Energy Conservation and Renewable sources of Energy	3-0-0	3
CH 414	Nanotechnology in Catalysis	3-0-0	3
CH 415	Fluidization Engineering	3-1-0	4
CH 417	Modern Separation Processes in Chemical Engineering	3-0-0	3
CH 418	Recent Separation Technologies	3-0-0	3
CH 419	Computational Fluid Dynamics	3-1-0	4
CH 427	Colloid and Interfacial Engineering	3-0-0	3
CH 611	Advanced Fluid Dynamics	3-1-0	4
CH 613	Advanced Mass Transfer	3-1-0	4
CH 615	Advanced Heat Transfer	3-1-0	4

Sub discipline: Process Engineering & Technology

CH 220	Chemical Engg. Thermodynamics	3-1-0	4
CH 221	Fundamentals of Biochemical Engg	3-0-0	3
CH 223	Chemical Process Technology	3-0-0	3
CH 224	Polymer Science and Technology	3-0-0	3
CH 225	Chemical Process Calculations	3-1-0	4
CH 226	Fuels and Combustion	3-0-0	4

CH 227	Fertilizer Technology	3-0-0	3
CH 228	Treatment of Industrial Effluents	3-0-0	3
CH 229	Basic Chemical Engineering	3-0-0	3
CH 321	Fundamentals of Biochemical Engineering	3-0-0	3
CH 322	Environmental Biotechnology	3-0-0	3
CH 323	Energy Conservation and Renewable sources of Energy	3-0-0	3
CH 324	Particulate Science and Technology	3-0-0	3
CH 329	Process Plant Safety	3-0-0	3
CH 330	Petroleum Refinery Engg. and Petrochemicals	3-0-0	3
CH 414	Nanotechnology in Catalysis	3-0-0	3
CH 421	Reaction Kinetics and Catalysis	3-1-0	4
CH 422	Simulation, Modeling and Optimisation of Chemical Process	3-1-0	4
CH 425	Environmental Engineering	3-0-0	3
CH 426	Coal Processing Technology	3-0-0	3
CH 427	Colloid and Interfacial Engineering	3-0-0	3
CH 428	Disaster Management in Chemical Industries	3-0-0	3
CH 621	Bioenergy Engineering	3-1-0	4
CH 623	Environmental Management System	3-1-0	4
CH 625	Bioprocess Engineering	3-1-0	4
CH 629	Interfacial Science and Engineering	3-1-0	4

Sub discipline:	**Design and Simulation**		
CH 330	Petroleum Refinery Engineering and Petrochemicals	3-0-0	3
CH 331	Process Instrumentation	3-0-0	3
CH 332	Process Equipment Design	3-1-0	4
CH 334	Process Dynamics and Control	3-1-0	4
CH 335	Applied Statistics for Chemical Engineers	3-0-0	3
CH 336	Chemical Engineering Mathematics	3-1-0	4
CH 337	Equipment Design (Mech. Aspects)	3-1-0	4
CH 432	Optimization Techniques in Process Design	3-0-0	3
CH 434	Project Engineering	3-0-0	3
CH 439	Non-Traditional Optimization Techniques	3-0-0	3
CH 631	Process Plant Simulation	3-1-0	4
CH 632	Advanced Process Control	3-1-0	4
CH 638	Advanced Reaction Engineering & Reactor Design	3-1-0	4

Sub discipline:	**Laboratory Courses**		
CH 270	Materials Handling Laboratory	0-0-3	2
CH 271	Process Technology Laboratory	0-0-3	2
CH 272	Fluid Dynamics Fundamentals Laboratory	0-0-3	2
CH 273	Fuels and Combustion Laboratory	0-0-3	2
CH 370	Computer Aided Design Laboratory – I	0-0-3	2
CH 371	Heat Transfer Fundamentals Laboratory	0-0-3	2

CH 372	Heat Transfer Design Laboratory	0-0-3	2
CH 373	Mass Transfer Fundamentals Laboratory	0-0-3	2
CH 374	Mass Transfer Design Laboratory	0-0-3	2
CH 375	Biotechnology Laboratory	0-0-3	2
CH 376	Process Instrumentation Laboratory	0-0-3	2
CH 377	Fluid Dynamics Applications Laboratory	0-0-3	2
CH 470	Process Simulation Laboratory.	0-0-3	2
CH 471	Chemical Reaction Engg. Laboratory	0-0-3	2
CH 473	Computer Aided Design Laboratory – II	0-0-3	2
CH 475	Process Dynamics and Control Laboratory	0-0-3	2
CH 670	Chemical Engineering Lab – III	0-0-3	2
CH 671	Chemical Engineering Lab – I	0-0-3	2
CH 672	Chemical Engineering Lab – IV	0-0-3	2
CH 673	Chemical Engineering Lab – II	0-0-3	2

Sub discipline:	**Project, Seminar and Special Courses (M.Tech)**		
CH 391	Special Topic in Chemical Engineering – I		3/4
CH 392	Special Topic in Chemical Engineering – II		3/4
CH 393	Special Laboratory in Chemical Engg – I	0-0-3	2
CH 394	Special Laboratory in Chemical Engg – II	0-0-3	2
CH 395	Engineering Product Development Project – I	0-0-6	4
CH 396	Engineering Product Development Project – II	0-0-6	4
CH 491	Research Project – I	0-0-3	2
CH 492	Research Project – II	0-0-3	2
CH 493	Seminar & Technical Writing – I	0-0-3	2
CH 494	Seminar and Technical Writing – II	0-0-3	2
CH 495	Short Term Industrial/ Research Experience	0-0-0	2
CH 496	Comprehensive Viva Voce	0-0-0	2
CH 681	Special Topics in Chemical Engineering – I		3/4
CH 687	Seminar & Technical Writing – III	0-0-3	2
CH 688	Seminar & Technical Writing – IV	0-0-3	2
CH 691	Summer Research/Industrial Project	0-0-0	4
CH 692	Comprehensive Viva Voce	0-0-0	4
CH 693	Research Project – III(Summer)	0-0-0	10
CH 694	Research Project Work – IV	0-0-0	10
CH 695	Research Project Work – V	0-0-30	20

DEPARTMENT OF CERAMIC ENGINEERING

Curriculum of B. Tech (Ceramic Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Mathematics - I		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		**15-5-15**	**30**

SECOND SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Mathematics - II		3-1-0	4
2	PH 102	Physics - II		3-1-0	4
3	CS 102	Data Structures and Algorithm		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 - II		0-0-3	2
		TOTAL		**15-5-15**	**30**

THIRD SEMESTER

Sl. No	Sub.Code	Subjects	L-T- P	Credits
1	MA 201	Mathematics – III	3-1-0	4
2	CR 211	Unit Operations in Ceramic Processing	3-1-0	4
3	CR 223	Materials Thermodynamics	3-0-0	3
4	CR 231	Properties of Ceramic Raw Materials	3-1-0	4

5		HS & Open Elective – I		3-1-0	3
6	MA 270 HS 270	Numerical Methods Laboratory Language Laboratory	OR	0-0-3	2
7	EE 270 EC 270	Electrical Engineering Laboratory– I Electronics Laboratory	OR	0-0-3	2
8	CR 271	Raw Materials Analysis Laboratory		0-0-3	2
9	CR 273	Ceramic Workshop		0-0-3	2
		TOTAL			**26**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 202	Mathematics – IV		3-1-0	4
2	CR 212	Ceramic Processing		3-1-0	4
3	CR 230	Science of Ceramic Materials		3-1-0	4
4		Professional Elective – I			3
5		HS & Open Elective – II		3-0-0	3
6	EC 270 EE 270	Basic Electronics Laboratory Electrical Engineering Laboratory – I	OR	0-0-3	2
7	HS 270 MA 270	Language Laboratory Numerical Methods Laboratory	OR	0-0-3	2
8	CR 272	Drawing of Refractory Lining and Joints		0-0-3	2
9	CR 274	Ceramic Fabrication Laboratory		0-0-3	2
		TOTAL			**26**

FIFTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CR 331	White ware Technology	3-0-0	3
2	CR 341	Physical Ceramics	3-1-0	4
3		Professional Elective – II		3/4
4		Professional Elective – III		3/4
5		HS & Open Elective – III	3-0-0	3
6	CR 371	High Temperature Processing Laboratory	0-0-3	2
7	CR 373	Whiteware Technology Laboratory	0-0-3	2
8	CR 375	Ceramic Characterization Laboratory	0-0-3	2
9	CR 377	Ceramic Equipment Design Laboratory	0-0-3	2
		TOTAL		**25**

SIXTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	CR 310	Refractories or Refractory	3-0-0	3
2	CR 322	Glass Technology	3-0-0	3
3		Professional Elective – IV		3/4
4		Professional Elective – V		3/4
5		HS & Open Elective – IV	3-0-0	3

6	CR 370	Refractories Technology Laboratory	0-0-3	2
7	CR 372	Glass Technology Laboratory	0-0-3	2
8	CR 374	Ceramic Product Development Laboratory	0-0-3	2
9	CR 376	Cement Technology Laboratory	0-0-3	2
		TOTAL		**25**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	CR 411	Advanced Ceramics	3-1-0	4
2		Professional Elective – VI	3-1-0	4
3		Professional Elective – VII	3-1-0	4
4		HS & Open Elective – V	3-0-0	3
5	CR 471	Advanced Ceramics Laboratory	0-0-3	2
6	CR 491	Research Project – I	0-0-6	4
7	CR 493	Seminar and Technical Writing – I	0-0-3	2
8	CR 495	Short term Industrial/Research Experience	0-0-3	2
		TOTAL		**25**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Elective – VIII		4
2		Professional Elective – IX		3/4
3		Professional Elective – X		3/4
4		HS & Open Elective – VI	3-0-0	3
5	CR 492	Research Project – II	0-0-9	6
6	CR 494	Seminar and Technical Writing – II	0-0-3	2
7	CR 496	Comprehensive Viva Voce	0-0-0	2
		TOTAL		**23/25**

Curriculum of M.Tech Dual Degree

[1st - 6th Semester curricula are common with B.Tech. Ceramic Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	CR 631	Structure & Properties of Engineering Ceramics	3-1-0	4
2	CR 611	Principles of Ceramic Processing & Fabrication	3-1-0	4
3		Professional Elective – VI (B.Tech.)	3-1-0	4
4		Professional Elective – VII (B.Tech.)	3-1-0	4
5	CR 671	Instrumental Analysis Laboratory	0-0-3	2
7	CR 673	Characterization of Ceramic Products Laboratory	0-0-3	2
8	CR 491	Research Project – I	0-0-3	2
9	CR 493	Seminar and Technical Writing – I	0-0-3	2
10	CR 691	Short Term Industrial /Research Experience	0-0-0	2
		TOTAL		**26**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	CR 632	Advances in Phase Diagrams	3-1-0	4
2	CR 641	Nanomaterials	3-1-0	4
3		Professional Elective – VIII (B.Tech.)	3-1-0	4
4		Professional Elective – IX (B.Tech.)		3/4
5		Professional Elective – X (B.Tech.)		3/4
6	CR 672	Electroceramics Laboratory	0-0-3	2
7	CR 674	Process Ceramics Laboratory	0-0-3	2
8	CR 494	Seminar and Technical Writing – II	0-0-3	2
9	CR 492	Research Project – II	0-0-3	2
		TOTAL		**26/28**

NINTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Electives – I (M.Tech)	3-1-0	4
2		Professional Electives – II (M.Tech)	3-1-0	4
3		Professional Electives – III (M.Tech)	3-1-0	4
4	CR 687	Seminar and Technical Writing – III	0-0-3	2
5	CR 693	Research Project – III(Summer)	0-0-0	10
6	CR 694	Research Project – IV	0-0-0	10
		TOTAL		**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	CR 688	Seminar and Technical Writing – IV	0-0-3	2
2	CR 692	Comprehensive Viva – Voce	0-0-0	4
3	CR 695	Research Project - V	0-0-30	20
		TOTAL		**26**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subject	L-T- P	Credits	Offered to
1.	CR 226	Pollution & Waste Management in Ceramic Industry	3-0-0	3	#
2.	CR 244	Introduction to Engineering Materials	3-0-0	3	#
3.	CR 248	Fuels, Furnace and Stoichiometry	3-0-0	3	#
4.	CR 320	Science of Sintering	3-1-0	4	#
5.	CR 325	Computational Materials Science	3-0-0	3	#
6.	CR 327	Interface Science & Sol- Gel Processing	3-1-0	4	#
7.	CR 330	Fuel Cell & Batteries	3-1-0	4	#
8.	CR 333	Heat Transfer and Fluid Flow	3-1-0	4	#
9.	CR 335	Instrumental Characterization	3-1-0	4	#
10.	CR 336	Cement Technology	3-1-0	4	#
11.	CR 346	Nanoceramics	3-1-0	4	#

12.	CR 391	Special Topic in Ceramic Engineering – I		3/4	#
13.	CR 392	Special Topic in Ceramic Engineering – II		3/4	#
14.	CR 393	Special Laboratory in Ceramic Engg – I	0-0-3	2	#
15.	CR 394	Special Laboratory in Ceramic Engg – II	0-0-3	2	#
16.	CR 395	Engineering Product Development Project – I	0-0-6	4	#
17.	CR 396	Engineering Product Development Project – II	0-0-6	4	#
18.	CR 415	Bio-ceramics	3-0-0	3	#
19.	CR 416	Application of Refractories	3-1-0	4	#
20.	CR 417	Unshaped Refractories	3-1-0	4	#
21.	CR 420	Glass Ceramic Technology	3-1-0	4	#
22.	CR 421	Glasses for Advanced Technical Application	3-1-0	4	#
23.	CR 422	Ceramic Equipment Design	3-0-0	3	#
24.	CR 424	Composite Materials	3-0-0	3	#
25.	CR 426	Tribology of Materials	3-0-0	3	#
26.	CR 433	Sensor Technology	3-0-0	3	#
27.	CR 435	Functional Materials & Devices	3-0-0	3	#
28.	CR 441	Electrical and Magnetic Ceramics	3-1-0	4	#
29.	CR 445	Application of Phase Diagrams	3-1-0	4	#
30.	CR 446	Thin Film and Coating	3-0-0	3	#
31.	CR 610	Shaped and Unshaped Refractories	3-1-0	4	$
32.	CR 612	Refractories for Metallurgical & Allied Processes	3-1-0	4	$
33.	CR 614	Advanced Structural Ceramics	3-1-0	4	$
34.	CR 617	Advances in Bio-ceramics	3-1-0	4	$
35.	CR 621	Energetics	3-1-0	4	$
36.	CR 624	Advanced Composites	3-1-0	4	$
37.	CR 633	Advanced Electro ceramics	3-1-0	4	$
38.	CR 635	High Temperature Ceramic Processing	3-1-0	4	$
39.	CR 636	Science of Sol-Gel Processing	3-1-0	4	$
40.	CR 643	Techniques of Materials Characterization	3-1-0	4	$

***Notes:** # (B.Tech. and all dual degree courses), $(only for dual degree courses)*

PROFESSIONAL ELECTIVES FROM OTHER DEPARTMENTS

Sl. No	Sub. Code	Subject	L-T- P	Credits
1	MM 606	X-Ray & Electron Microscopy	3-1-0	4
2	MM 646	Composite Materials	3-1-0	4
3	BM 321	Biomaterials	3-0-0	3
4	CE 318	Finite Element Method	3-1-0	4
5	CH 427	Colloid and Interfacial Engineering	3-0-0	3
6	CS 213	Principles of Programming Language	3-0-0	3
7	CY 413	Spectroscopic Methods of Analysis	3-0-0	3
8	CY 518	Polymer Chemistry	3-1-0	4
9	CY 531	Thermodynamics and Chemical Equilibra	3-1-0	4
10	CY 536	Colloids & Surface Chemistry	3-0-0	3

11	CY 537	Advanced Solid State Chemistry	3-0-0	3
12	MA 522	Operations Research	3-1-0	4
13	ME 410	Advanced Mechanics of Solids	3-0-0	3
14	ME 440	Industrial Management	3-0-0	3
15	MM 256	Transport Phenomena	3-0-0	3
16	MM 356	Pollution in Metallurgical Industry & its Control	3-0-0	3
17	MM 359	Engineering Polymers & Composites	3-1-0	4
18	PH 351	Science of Nanomaterials	3-0-0	3

COURSES OFFERED AS OPEN ELECTIVES

(Normally not offered to students of Ceramic Engineering)

Sl. No	Sub. Code	Subject	L-T- P	Credits	Non Eligible Branches
1	CR 219	Introduction to Ceramics	3-0-0	3	-
2	CR 249	Materials Science & Engineering	3-0-0	3	MM
3	CR 339	Ceramics in Electronic Applications	3-0-0	3	-
4	CR 348	Introduction to Engineering Ceramics	3-0-0	3	-
5	CR 418	Nanomaterials	3-0-0	3	PH
6	CR 419	Biomatters for Artificial Implants	3-0-0	3	BM, BT

SUMMARY OF COURSES

Sub Discipline:	Industrial Ceramics		
CR 211	Unit Operations in Ceramic Processing	3-1-0	4
CR 212	Ceramic Processing	3-1-0	4
CR 219	Introduction to Ceramics	3-0-0	3
CR 310	Refractories or Refractory	3-0-0	3
CR 411	Advanced Ceramics	3-1-0	4
CR 415	Bio-ceramics	3-0-0	3
CR 416	Application of Refractories	3-1-0	4
CR 417	Unshaped Refractories	3-1-0	4
CR 418	Nanomaterials	3-0-0	3
CR 419	Biomaterials for Artificial Implants	3-0-0	3
CR 610	Shaped and Unshaped Refractories	3-1-0	4
CR 611	Principles of Ceramic Processing & Fabrication	3-1-0	4
CR 612	Refractories for Metallurgical & Allied Processes	3-1-0	4
CR 614	Advanced Structural Ceramics	3-1-0	4
CR 617	Advances in Bio-ceramics	3-1-0	4

Sub Discipline:	Structural and Advanced Ceramics		
CR 223	Materials Thermodynamics	3-0-0	3
CR 226	Pollution & Waste Management in Ceramic Industry	3-0-0	3
CR 320	Science of Sintering	3-1-0	4
CR 322	Glass Technology	3-0-0	3

CR 325	Computational Materials Science	3-0-0	3
CR 327	Interface Science & Sol- Gel Processing	3-1-0	4
CR 420	Glass Ceramic Technology	3-1-0	4
CR 421	Glasses for Advanced Technical Application	3-1-0	4
CR 422	Ceramic Equipment Design	3-0-0	3
CR 424	Composite Materials	3-0-0	3
CR 426	Tribology of Materials	3-0-0	3
CR 621	Energetics	3-1-0	4
CR 624	Advanced Composites	3-1-0	4
CR 426	Tribology of Materials	3-0-0	3

Sub Discipline:	**Electroceramics**		
CR 230	Science of Ceramic Materials	3-1-0	4
CR 231	Properties of Ceramic Raw Materials	3-1-0	4
CR 330	Fuel Cell & Batteries	3-1-0	4
CR 331	Whiteware Technology	3-0-0	3
CR 333	Heat Transfer and Fluid Flow	3-1-0	4
CR 335	Instrumental Characterization	3-1-0	4
CR 336	Cement Technology	3-1-0	4
CR 433	Sensor Technology	3-0-0	3
CR 435	Functional Materials & Devices	3-0-0	3
CR 631	Structure & Properties of Engineering Ceramics	3-1-0	4
CR 632	Advances in Phase Diagrams	3-1-0	4
CR 633	Advanced Electro ceramics	3-1-0	4
CR 635	High Temperature Ceramic Processing	3-1-0	4
CR 636	Science of Sol-Gel Processing	3-1-0	4

Sub Discipline:	**Nano and Bioceramics**		
CR 244	Introduction to Engineering Materials	3-0-0	3
CR 248	Fuels, Furnace and Stoichiometry	3-0-0	3
CR 341	Physical Ceramics	3-1-0	4
CR 344	Microstructural Design in Ceramics	3-0-0	3
CR 346	Nanoceramics	3-1-0	4
CR 348	Introduction to Engineering Ceramics	3-0-0	3
CR 441	Electrical and Magnetic Ceramics	3-1-0	4
CR 445	Application of Phase Diagrams	3-1-0	4
CR 446	Thin Film and Coating	3-0-0	3
CR 641	Nanomaterials	3-1-0	4
CR 643	Techniques of Materials Characterization	3-1-0	4

Sub Discipline:	**Laboratory Courses**		
CR 271	Raw Materials Analysis Laboratory	0-0-3	2
CR 272	Drawing of Refractory Lining and Joints	0-0-3	2

CR 273	Ceramic Workshop	0-0-3	2
CR 274	Ceramic Fabrication Laboratory	0-0-3	2
CR 370	Refractories Technology Laboratory	0-0-3	2
CR 371	High Temperature Processing Laboratory	0-0-3	2
CR 372	Glass Technology Laboratory	0-0-3	2
CR 373	Whiteware Technology Laboratory	0-0-3	2
CR 374	Ceramic Product Development Laboratory	0-0-3	2
CR 375	Ceramic Characterization Laboratory	0-0-3	2
CR 376	Cement Technology Laboratory	0-0-3	2
CR 377	Ceramic Equipment Design Laboratory	0-0-3	2
CR 471	Advanced Ceramics Laboratory	0-0-3	2
CR 671	Instrumental Analysis Laboratory	0-0-3	2
CR 672	Electroceramics Laboratory	0-0-3	2
CR 673	Characterization of Ceramic Products Laboratory	0-0-3	2
CR 674	Process Ceramics Laboratory	0-0-3	2

Sub discipline:	**Project, Seminar and Special Courses**		
CR 271	Raw Materials Analysis Laboratory	0-0-3	2
CR 272	Drawing of Refractory Lining and Joints	0-0-3	2
CR 273	Ceramic Workshop	0-0-3	2
CR 274	Ceramic Fabrication Laboratory	0-0-3	2
CR 370	RefractoriesTechnology Laboratory	0-0-3	2
CR 371	High Temperature Processing Laboratory	0-0-3	2
CR 372	Glass Technology Laboratory	0-0-3	2
CR 373	Whiteware Technology Laboratory	0-0-3	2
CR 374	Ceramic Product Development Laboratory	0-0-3	2
CR 375	Ceramic Characterization Laboratory	0-0-3	2
CR 376	Cement Technology Laboratory	0-0-3	2
CR 377	Ceramic Equipment Design Laboratory	0-0-3	2
CR 391	Special Topic in Ceramic Engineering – I		3/4
CR 392	Special Topic in Ceramic Engineering – II		3/4
CR 393	Special Laboratory in Ceramic Engg – I	0-0-3	2
CR 394	Special Laboratory in Ceramic Engg – II	0-0-3	2
CR 395	Engineering Product Development Project – I	0-0-6	4
CR 396	Engineering Product Development Project – II	0-0-6	4
CR 471	Advanced Ceramics Laboratory	0-0-3	2
CR 491	Research Project – I	0-0-6	4
CR 492	Research Project – II	0-0-9	6
CR 493	Seminar and Technical Writing – I	0-0-3	2
CR 494	Seminar and Technical Writing – II	0-0-3	2
CR 495	Short Term Industrial/Research Experience	0-0-0	2
CR 496	Comprehensive Viva Voce	0-0-0	2

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Curriculum of B.Tech (Computer Science and Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Mathematics – I		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				**15-5-15**	**30**

SECOND SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Mathematics – II		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				**15-5-15**	**30**

THIRD SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MA 201	Mathematics – III	3-1-0	4
2	CS 211	Discrete Mathematics	3-1-0	4
3	CS 241	Analog Electronics	3-0-0	3
4	CS 243	Digital Electronics	3-0-0	3

5		HS and Open Elective – I		3-0-0	3
6	CS 271	Data Structure Laboratory		0-0-3	2
7	EE 270	Electrical Engineering Laboratory – I	OR	0-0-3	2
	EC 270	Basic Electronics Laboratory			
8	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
9	CS 273	Digital Electronics Laboratory		0-0-3	2
TOTAL					**25**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects		L-T-P	Credits
1	MA 202	Mathematics – IV		3-1-0	4
2	CS 222	Database Management Systems		3-0-0	3
3	CS 242	Computer Organization and Architecture		3-1-0	4
4		Professional Elective – I		3-0-0	3
5		HS and Open Elective – II		3-0-0	3
6	CS 272	Database Laboratory		0-0-3	2
7	EE 270	Electrical Engineering Laboratory – I	OR	0-0-3	2
	EC 270	Basic Electronics Laboratory			
8	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
9	CS 274	VHDL Programming Laboratory		0-0-3	2
TOTAL					**25**

FIFTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS 321	Data Communication	3-0-0	3
2	CS 331	Theory of Computation	3-1-0	4
3	CS 341	Microprocessors and Microcontrollers	3-1-0	4
4		Professional Elective – II	3-0-0	3
5		HS and Open Elective – III	3-0-0	3
6	CS 371	Data Communication Laboratory	0-0-3	2
7	CS 373	Microprocessor Laboratory	0-0-3	2
8		Elective Laboratory – I	0-0-3	2
9		Elective Laboratory – II	0-0-3	2
TOTAL				**25**

SIXTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS 312	Systems Analysis and Design	3-0-0	3
2	CS 334	Operating Systems Design	3-0-0	3
3		Professional Elective – III	3-1-0	4
4		Professional Elective – IV	3-1-0	4

5		HS and Open Elective – IV	3-0-0	3
6	CS 372	Systems Analysis and Design Laboratory	0-0-3	2
7	CS 374	Operating Systems Laboratory	0-0-3	2
8		Elective Laboratory – III	0-0-3	2
9		Elective Laboratory – IV	0-0-3	2
TOTAL				**25**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS 421	Computer Networks	3-0-0	3
2		Professional Elective – V		3/4
3		Professional Elective – VI		3/4
4		Professional Elective – VII		3/4
5		HS and Open Elective – V	3-0-0	3
6	CS 471	Network Laboratory	0-0-3	2
7	CS 491	Research Project – I	0-0-6	4
8	CS 493	Seminar and Technical Writing – I	0-0-3	2
9	CS 495	Short term Industrial/Research Experience	0-0-3	2
TOTAL				**25/28**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS 412	Software Engineering	3-1-0	4
2		Professional Elective – VIII		3/4
3		Professional Elective – IX		3/4
4		HS and Open Elective – VI	3-0-0	3
5	CS 472	Software Engineering Laboratory	0-0-3	2
6	CS 492	Research Project – II	0-0-9	6
7	CS 494	Seminar and Technical Writing – II	0-0-3	2
8	CS 496	Comprehensive Viva – Voce	0-0-0	2
TOTAL				**25/27**

Curriculum of M.Tech Dual Degree (Specialization: Computer Science & Engineering)

[1st - 6th Semester curricula are common with B.Tech. Computer Science & Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS 616	Algorithm Design	3-1-0	4
2	CS 625	Data Mining and Data Warehousing	3-1-0	4
3		Professional Elective –V (B.Tech.)		3/4
4		Professional Elective –VI (B.Tech.)		3/4
5		Professional Elective –VII (B.Tech.)		3/4
6		Data Mining Laboratory– I (M.Tech.)	0-0-3	2

7		Data Mining Laboratory – II (M.Tech.)	0-0-3	2
8	CS 491	Research Project – I	0-0-3	2
9	CS 685	Seminar and Technical Writing – I	0-0-3	2
10	CS 691	Short Term Industrial/Research Experience	0-0-0	2
		TOTAL		**27/30**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS 612	Software Engineering	3-1-0	4
2	CS 622	Design of Computer Networks	3-1-0	4
3		Professional Elective –VIII (B.Tech.)		3/4
4		Professional Elective – IX (B.Tech.)		3/4
5		Professional Elective –X (B.Tech.)		3/4
6	CS 670	Computer Programming Lab – II	0-0-3	2
7	CS 672	Software Engineering Laboratory	0-0-3	2
8	CS 492	Research Project – II	0-0-3	2
9	CS 686	Seminar and Technical Writing – II	0-0-3	2
		TOTAL		**25/28**

NINTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Elective – XI (M.Tech.)	3-1-0	4
2		Professional Elective – XII (M.Tech.)	3-1-0	4
3		Professional Elective – XIII (M.Tech.)	3-1-0	4
4	CS 687	Seminar & Technical Writing – III	0-0-3	2
5	CS 693	Research Project– III	0-0-0	10
6	CS 693	Research Project – IV	0-0-0	10
		TOTAL	**9-3-18**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS 688	Seminar and Technical Writing – IV	0-0-3	2
2	CS 692	Comprehensive Viva	0-0-0	4
3	CS 695	Research Project – V	0-0-30	20
		TOTAL	**0-0-33**	**26**

Curriculum of M.Tech Dual Degree (Specialization: Information Security)

[1st - 6th Semester curricula are common with B.Tech. Computer Science & Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS 621	Cryptographic Foundations	3-1-0	4
2	CS 631	Information Theory Coding	3-1-0	4

3		Professional Elective –V (B. Tech.)		3/4
4		Professional Elective – VI (B. Tech.)		3/4
5		Professional Elective – VII (B. Tech.)		3/4
6	CS 676	Cryptography Laboratory – I	0-0-3	2
7	CS 680	Cryptography Laboratory – II	0-0-3	2
8	CS 491	Research Project – I	0-0-3	2
9	CS 685	Seminar and Technical Writing – I	0-0-3	2
10	CS 691	Short term Industrial/Research Experience	0-0-0	2
TOTAL				**27/30**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS 629	Network Security	3-1-0	4
2	CS 626	Intrusion Detection Systems	3-1-0	4
3		Professional Elective –VIII (B.Tech.)		3/4
4		Professional Elective – IX (B.Tech.)		3/4
5		Professional Elective –X (B.Tech.)		3/4
6	CS 678	OS and Database Security Laboratory [Lab 3 (M.Tech.)]	0-0-3	2
7		Elective Lab – VI [Lab 4 (M.Tech.)]	0-0-3	2
8	CS 492	Research Project – II	0-0-3	2
9	CS 686	Seminar and Technical Writing – II	0-0-3	2
TOTAL				**25/28**

NINTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Elective – XI (M.Tech.)	3-1-0	4
2		Professional Elective – XII (M.Tech.)	3-1-0	4
3		Professional Elective – XIII (M.Tech.)	3-1-0	4
4	CS 687	Seminar & Technical Writing – III	0-0-3	2
5	CS 693	Research Project –III(Summer)	0-0-0	10
6	CS 694	Research Project – IV	0-0-0	10
TOTAL			**9-3-3**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS 688	Seminar & Technical Writing – IV	0-0-3	2
2	CS 692	Comprehensive Viva-Voce	0-0-0	4
3	CS 695	Research Project – IV	0-0-30	20
TOTAL			**0-0-33**	**26**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subjects	L-T- P	Credits	Offered to
1	CS 213	Principles of Programming Languages	3-1-0	4	#
2	CS 315	Optimization Techniques	3-1-0	4	#

3	CS 325	Cryptographic Foundation	3-0-0	3	@
4	CS 332	Algorithm Analysis and Design	3-1-0	4	#
5	CS 335	Computer Graphics & Multimedia	3-0-0	3	#
6	CS 336	Digital Signal Processing	3-1-0	4	@
7	CS 338	System Software	3-1-0	4	#
8	CS 375	Computer Graphics Laboratory	0-0-3	2	#
9	CS 376	Digital Signal Processing Laboratory	0-0-3	2	#
10	CS 377	Computational Statistics Laboratory	0-0-3	2	#
11	CS 378	Systems Programming Laboratory	0-0-3	2	#
12	CS 379	Network Design and Simulation Laboratory	0-0-3	2	#
13	CS 380	Simulation and Modeling Laboratory	0-0-3	2	$
14	CS 384	Algorithm Analysis Design Laboratory	0-0-3	2	#
15	CS 391	Special Topics in Computer Science – I	3-1-0	4	#
16	CS 392	Special Topics in Computer Science – II	3-1-0	4	#
17	CS 393	Special Laboratory in Comp. Sc. Engg– I	0-0-3	2	#
18	CS 394	Special Laboratory in Comp. Sc. Engg– II	0-0-3	2	#
19	CS 395	Engineering Product Development Project – I	0-0-6	4	#
20	CS 396	Engineering Product Development Project – II	0-0-6	4	#
21	CS 396	Engineering Product Development Project - II	0-0-6	4	@
22	CS 414	Software Project, Process and Quality Management	3-1-0	4	@
23	CS 416	Bioinformatics	3-1-0	4	@
24	CS 417	Graph Theory and Network Algorithms	3-0-0	3	$
25	CS 418	Real Time Systems	3-1-0	4	@
26	CS 423	Ad-hoc and Wireless Networks	3-1-0	4	@
27	CS 425	Data Warehousing and Mining	3-1-0	4	@
28	CS 427	Network Security	3-1-0	4	#
29	CS 430	Information Theory and Coding	3-1-0	4	@
30	CS 431	Compiler Design	3-0-0	3	#
31	CS 432	Distributed Operating Systems	3-1-0	4	@
32	CS 434	Image Processing	3-0-0	3	#
33	CS 435	Artificial Intelligence	3-0-0	3	#
34	CS 437	Soft Computing	3-0-0	3	$
35	CS 438	Pattern Recognition	3-1-0	4	@
36	CS 439	Computer Vision	3-0-0	3	$
37	CS 441	Advanced Computer Architecture	3-1-0	4	@
38	CS 443	Embedded Systems	3-1-0	4	@
39	CS 444	Cluster and Grid Computing	3-1-0	4	@
40	CS 445	Parallel Algorithms	3-1-0	4	@
41	CS 449	VLSI System Design	3-1-0	4	@
42	CS 473	Real Time Systems Laboratory	0-0-3	2	#
43	CS 474	Image Processing Laboratory	0-0-3	2	#
44	CS 477	Soft Computing Laboratory	0-0-3	2	#

45	CS 478	Parallel Computing Laboratory	0-0-3	2	#
46	CS 479	Advanced Linux Programming Laboratory	0-0-3	2	#
47	CS 481	Compiler Design Laboratory	0-0-3	2	#
48	CS 482	Distributed Computing Laboratory	0-0-3	2	#
49	CS 485	Artificial Intelligence Laboratory	0-0-3	2	#
50	CS 489	Computer Vision Laboratory	0-0-3	2	#
51	CS 614	Software Project, Process and Quality Management	3-1-0	4	$
52	CS 618	Real Time Systems Design	3-1-0	4	$
53	CS 623	Ad-hoc and Wireless Networks	3-1-0	4	$
54	CS 625	Data Mining and Data Warehousing	3-1-0	4	$
55	CS 632	Distributed Operating Systems	3-1-0	4	$
56	CS 633	Game Theory	3-1-0	4	$
57	CS 634	Bioinformatics	3-1-0	4	$
58	CS 636	Image Processing	3-1-0	4	$
59	CS 637	Digital Signal Processing	3-1-0	4	$
60	CS 638	Pattern Recognition	3-1-0	4	$
61	CS 641	Advanced Computer Architecture	3-1-0	4	$
62	CS 642	Cluster and Grid Computing	3-1-0	4	$
63	CS 643	Embedded Systems	3-1-0	4	$
64	CS 645	Parallel Algorithms	3-1-0	4	$
65	CS 649	VLSI System Design	3-1-0	4	$

***Notes:** # (B.Tech. and all dual degree courses), $(only for dual degree courses), @ (only for B.Tech courses)*

PROFESSIONAL ELECTIVES FROM OTHER DEPARTMENTS

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1.	BM 368	Bioinformatics	3-0-0	3
2.	EC 314	Digital Communication	3-0-0	3
3.	EC 322	Embedded Systems	3-0-0	3
4.	EC 370	Embedded Systems Laboratory	0-0-3	2
5.	EC 411	Coding Theory and Secure Communication	3-0-0	3
6.	EC 413	Optical Communication	3-1-0	4
7.	EC 414	Information Theory and Coding	3-1-0	4
8.	EC 415	Mobile Communication	3-1-0	4
9.	EC 419	Computer Communication and Network	3-1-0	4
10.	EC 421	Digital VLSI Design	3-1-0	4
11.	EC 423	HDL and High Level VLSI	3-1-0	4
12.	EC 442	Advanced Techniques in Digital Signal Processing	3-1-0	4
13.	EC 443	Digital Image Processing	3-0-0	3
14.	EC 444	Soft Computing	3-1-0	4
15.	EC 446	Adaptive Signal Processing	3-1-0	4
16.	EC 448	Evolutionary Computing Techniques	3-1-0	4

17.	EC 471	Optical communication Laboratory	0-0-3	2
18.	EC 472	Image Processing Laboratory	0-0-3	2
19.	EC 473	High Level VLSI Laboratory	0-0-3	2
20.	EC 475	VLSI Laboratory	0-0-3	2
21.	EC 477	Mobile Communication Laboratory	0-0-3	2
22.	EE 456	Robotics and Computer Vision	3-0-0	3
23.	MA 517	Lie Algebra	3-1-0	4
24.	MA 518	Advanced Complex Analysis	3-1-0	4
25.	MA 521	Combinatorics	3-1-0	4
26.	MA 523	Discrete Mathematics	3-1-0	4
27.	MA 524	Statistical Methods	3-1-0	4
28.	MA 525	Ergodic Theory	3-1-0	4
29.	MA 527	Fractals	3-1-0	4
30.	MA 529	Information Theory	3-1-0	4
31.	MA 534	Geometry of Robotics	3-1-0	4
32.	MA 548	Field Theory	3-1-0	4
33.	MA 550	Coding Theory	3-1-0	4
34.	MA 552	Fuzzy logic and Set Theory	3-1-0	4
35.	MA 553	Optimization Techniques	3-1-0	4
36.	MA 555	Stochastic Processes	3-1-0	4
37.	MA 556	Number Theory	3-1-0	4
38.	ME 434	Computer Graphics for CAD/CAM	3-0-0	3

COURSES OFFERED AS OPEN ELECTIVES

(Normally not offered to the students of Computer Science & Engineering)

Sl. No	Sub. Code	Subjects	L-T-P	Credits	Non Eligible Branches
1.	CS 212	Object Oriented Programming and Web Applications using C#	3-0-0	3	-
2.	CS 314	Simulation and Modeling	3-0-0	3	-
3.	CS 326	Data Communication and Computer Networks	3-0-0	3	EC
4.	CS 327	Relational Database management Systems	3-0-0	3	-
5.	CS 333	Operating Systems	3-0-0	3	-
6.	CS 343	Digital Logic Design	3-0-0	3	EC, EE
7.	CS 413	Advanced Programming Skills	3-0-0	3	-
8.	CS 433	Algorithm Design	3-0-0	3	-
9.	CS 436	Soft Computing Techniques	3-0-0	3	EC, EE
10.	CS 440	Cryptographic Foundations	3-0-0	3	-
11.	CS 442	Computer System Architecture	3-0-0	3	EC, EE
12.	CS 446	Graph Theory	3-0-0	3	-
13.	CS 448	Artificial Intelligence & Neural Network	3-0-0	3	-
14.	CS 450	Multimedia & Computer Vision	3-0-0	3	-
15.	CS 451	Image Processing	3-0-0	3	-

SUMMARY OF COURSES

Sub-Discipline:	Software Engineering		
CS 211	Discrete Mathematics	3-1-0	4
CS 212	Object Oriented Programming and Web Application using C#	3-0-0	3
CS 213	Principles of Programming Languages	3-1-0	4
CS 312	Systems Analysis and Design	3-0-0	3
CS 314	Simulation and Modeling	3-0-0	3
CS 315	Optimization Techniques	3-1-0	4
CS 412	Software Engineering	3-1-0	4
CS 413	Advanced Programming Skills	3-0-0	3
CS 414	Software Project, Process and Quality Management	3-1-0	4
CS 416	Bioinformatics	3-1-0	4
CS 417	Graph Theory and Network Algorithms	3-0-0	3
CS 418	Real Time Systems	3-1-0	4
CS 612	Software Engineering	3-1-0	4
CS 614	Software Project, Process and Quality Management	3-1-0	4
CS 616	Algorithm Design	3-1-0	4
CS 618	Real Time Systems Design	3-1-0	4

Sub-Discipline:	Network and Secured Computing		
CS 222	Database Management Systems	3-0-0	3
CS 321	Data Communication	3-0-0	3
CS 325	Cryptographic Foundation	3-0-0	3
CS 326	Data Communication and Computer Networks	3-0-0	3
CS 327	Relational Database Management Systems	3-0-0	3
CS 421	Computer Networks	3-0-0	3
CS 423	Ad-hoc and Wireless Networks	3-1-0	4
CS 425	Data Warehousing and Mining	3-1-0	4
CS 427	Network Security	3-1-0	4
CS 621	Cryptographic Foundations	3-1-0	4
CS 622	Design of Computer Networks	3-1-0	4
CS 623	Ad-hoc and Wireless Networks	3-1-0	4
CS 625	Data Mining and Data Warehousing	3-1-0	4
CS 629	Network Security	3-1-0	4

Sub-Discipline:	Intelligent Computing and Computer Vision		
CS 102	Data Structures and Algorithms	3-1-0	4
CS 331	Theory of Computation	3-1-0	4
CS 332	Algorithm Analysis and Design	3-1-0	4
CS 333	Operating Systems	3-0-0	3
CS 334	Operating Systems Design	3-0-0	3
CS 335	Computer Graphics and Multimedia	3-0-0	3

CS 336	Digital Signal Processing	3-1-0	4
CS 338	Systems Software	3-1-0	4
CS 430	Information Theory and Coding	3-1-0	4
CS 431	Compiler Design	3-0-0	3
CS 432	Distributed Operating Systems	3-1-0	4
CS 433	Algorithm Design	3-0-0	3
CS 434	Image Processing	3-0-0	3
CS 435	Artificial Intelligence	3-0-0	3
CS 436	Soft Computing Techniques	3-0-0	3
CS 437	Soft Computing	3-0-0	3
CS 438	Pattern Recognition	3-1-0	4
CS 439	Computer Vision	3-0-0	3
CS 440	Cryptographic Foundations	3-0-0	3
CS 450	Multimedia & Computer Vision	3-0-0	3
CS 451	Image Processing	3-0-0	3
CS 631	Information Theory and Coding	3-1-0	4
CS 632	Distributed Operating Systems	3-1-0	4
CS 633	Game Theory	3-1-0	4
CS 634	Bioinformatics	3-1-0	4
CS 635	Biometric Security	3-1-0	4
CS 636	Image Processing	3-1-0	4
CS 637	Digital Signal Processing	3-1-0	4
CS 638	Pattern Recognition	3-1-0	4

Sub-Discipline:	**Computer Hardware**		
CS 241	Analog Electronics	3-0-0	3
CS 242	Computer Organization and Architecture	3-1-0	4
CS 243	Digital Electronics	3-0-0	3
CS 341	Microprocessors and Microcontrollers	3-1-0	4
CS 343	Digital Logic Design	3-0-0	3
CS 440	Cryptographic Foundations	3-0-0	3
CS 441	Advanced Computer Architecture	3-1-0	4
CS 442	Computer System Architecture	3-0-0	3
CS 443	Embedded Systems	3-1-0	4
CS 444	Cluster and Grid Computing	3-1-0	4
CS 445	Parallel Algorithms	3-1-0	4
CS 446	Graph Theory	3-0-0	3
CS448	Artificial Intelligence & Neural Networks	3-0-0	3
CS 449	VLSI System Design	3-1-0	4
CS 641	Advanced Computer Architecture	3-1-0	4
CS 642	Cluster and Grid Computing	3-1-0	4
CS 643	Embedded Systems	3-1-0	4

CS 645	Parallel Algorithms	3-1-0	4
CS 649	VLSI System Design	3-1-0	4

Sub-Discipline:	Laboratory Courses		
CS 171	Computing Laboratory – I	0-0-3	2
CS 172	Computing Laboratory – II	0-0-3	2
CS 270	Analog Electronics Laboratory	0-0-3	2
CS 271	Data Structure Laboratory	0-0-3	2
CS 272	Database Laboratory	0-0-3	2
CS 273	Digital Electronics Laboratory	0-0-3	2
CS 274	VHDL Programming Laboratory	0-0-3	2
CS 371	Data Communication Laboratory	0-0-3	2
CS 372	Systems Analysis and Design Laboratory	0-0-3	2
CS 373	Microprocessor Laboratory	0-0-3	2
CS 374	Operating Systems Laboratory	0-0-3	2
CS 375	Computer Graphics Laboratory	0-0-3	2
CS 376	Digital Signal Processing Laboratory	0-0-3	2
CS 377	Computational Statistics Laboratory	0-0-3	2
CS 378	Systems Programming Laboratory	0-0-3	2
CS 379	Network Design and Simulation Laboratory	0-0-3	2
CS 380	Simulation & Modeling Laboratory	0-0-3	2
CS 384	Algorithm Analysis and Design Laboratory	0-0-3	2
CS 471	Network Laboratory	0-0-3	2
CS 472	Software Engineering Laboratory	0-0-3	2
CS 473	Real Time Systems Laboratory	0-0-3	2
CS 474	Image Processing Laboratory	0-0-3	2
CS 477	Soft Computing Laboratory	0-0-3	2
CS 478	Parallel Computing Laboratory	0-0-3	2
CS 479	Advanced Linux Programming Laboratory	0-0-3	2
CS 481	Compiler Design Laboratory	0-0-3	2
CS 482	Distributed Computing Laboratory	0-0-3	2
CS 485	Artificial Intelligence Laboratory	0-0-3	2
CS 489	Computer Vision Laboratory	0-0-3	2
CS 670	Computer Programming Lab – II	0-0-3	2
CS 672	Software Engineering Laboratory	0-0-3	2
CS 676	Cryptography Laboratory – I	0-0-3	2
CS 678	OS and Database Security Laboratory	0-0-3	2

Sub-Discipline:	Project, Seminar and Special Courses		
CS 391	Special Topics in Computer Science - I	3-1-0	4
CS 392	Special Topics in Computer Science - II	3-1-0	4
CS 393	Special Laboratory in Comp. Sc. Engg - I	0-0-3	2

CS 394	Special Laboratory in Comp. Sc. Engg - II	0-0-3	2
CS 395	Engineering Product Development Project - I	0-0-6	4
CS 396	Engineering Product Development Project - II	0-0-6	4
CS 491	Research Project – I	0-0-6	4
CS 492	Research Project – II	0-0-9	6
CS 493	Seminar and Technical Writing – I	0-0-3	2
CS 494	Seminar and Technical Writing – II	0-0-3	2
CS 495	Short term Industrial/Research Experience	0-0-0	2
CS 496	Comprehensive Viva – Voce	0-0-0	2
CS 680	Cryptography Laboratory – II	0-0-3	2
CS 685	Seminar and Technical Writing – I	0-0-3	2
CS 686	Seminar and Technical Writing – II	0-0-3	2
CS 687	Seminar & Technical Writing – III	0-0-3	2
CS 688	Seminar and Technical Writing – IV	0-0-3	2
CS 691	Summer Research / Industrial Project	0-0-0	4
CS 692	Comprehensive Viva-Voce	0-0-0	4
CS 693	Research Project – III	0-0-15	10
CS 694	Research Project – IV	0-0-30	20
CS 695	Research Project – V	0-0-30	20

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Curriculum of B. Tech (Electronics & Communication Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Mathematics – I		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			**15-5-15**	**30**

SECOND SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Mathematics – II		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithm		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 – II		0-0-3	2
	TOTAL			**15-5-15**	**30**

THIRD SEMESTER

Sl. No	Sub.Code	Subjects	L-T- P	Credits
1	MA 201	Mathematics – III	3-1-0	4
2	ME 250	Thermal Engineering	3-0-0	3
3	EC 201	Analog Electronics	3-1-0	4

4	EC 203	Networks	3-1-0	4
5		HS and Open Elective – I	3-0-0	3
6	MA 270	Numerical Methods Laboratory	0-0-3	2
7	ME 271	Thermal Engineering Laboratory	0-0-3	2
8	EC 270	Basic Electronics Laboratory	0-0-3	2
9	EC 273	Circuit Simulation Lab	0-0-3	2
		TOTAL		**26**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	MA 202	Mathematics – IV	3-1-0	4
2	EE 202	Electrical Engineering	3-1-0	4
3	EC 202	Digital Electronics	3-0-0	3
4		Professional Elective – I	3-0-0	3
5		HS and Open Elective – II (Management)	3-0-0	3
6	EE 270	Electrical Engineering Laboratory – I	0-0-3	2
7	EC 274	Analog Electronics Laboratory	0-0-3	2
8	EC 276	Digital Electronics Laboratory	0-0-3	2
9	HS 270	Language Laboratory	0-0-3	2
		TOTAL		**25**

FIFTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	EC 301	Microprocessors	3-0-0	3
2	EC 311	Analog Communication Systems	3-1-0	4
3	EC 331	Control System Engineering	3-1-0	4
4	EC 341	Digital Signal Processing	3-1-0	4
5		HS & Open Elective – III	3-0-0	3
6	EC 371	Microprocessors Laboratory	0-0-3	2
7	EC 373	Analog Communication Laboratory	0-0-3	2
8	EC 375	DSP Laboratory	0-0-3	2
9		Elective Laboratory – I	0-0-3	2
		TOTAL		**26**

SIXTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	EC 312	Electromagnetic Theory	3-0-0	3
2	EC 314	Digital Communication	3-0-0	3
3		Professional Elective – II	3-1-0	4
4		Professional Elective – III	3-0-0	3
5		HS and Open Elective – IV	3-0-0	3
6	EC 372	Digital Communication Laboratory	0-0-3	2
7		Elective Laboratory – II	0-0-3	2

8		Elective Laboratory – III	0-0-3	2
9	EC 382	Communication System Design Lab	0-0-3	2
		TOTAL		**24**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Elective – IV	3-1-0	4
2		Professional Elective – V	3-1-0	4
3		Professional Elective – VI	3-1-0	4
4		HS and Open Elective – V	3-0-0	3
5		Elective Lab – IV	0-0-3	2
6	EC 491	Research Project – I	0-0-6	4
7	EC 493	Seminar and Technical Writing – I	0-0-3	2
8	EC 495	Short term Industrial / Research Experience	0-0-3	2
		TOTAL		**25**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Elective – VIII	3-1-0	4
2		Professional Elective – IX	3-1-0	4
3		Professional Elective – X	3-1-0	4
4		HS and Open Elective – VI	3-0-0	3
5		Elective Laboratory – V	0-0-3	2
6	EC 492	Research Project – II	0-0-9	6
7	EC 494	Seminar and Technical Writing – II	0-0-3	2
8	EC 496	Comprehensive Viva Voce	0-0-0	2
		TOTAL		**27**

Curriculum of B. Tech (Electronics & Instrumentation Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Mathematics – I		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	**15-5-15**	**30**

SECOND SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Mathematics – II		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithm		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 – II		0-0-3	2
		TOTAL		**15-5-15**	**30**

THIRD SEMESTER

Sl. No	Sub.Code	Subjects	L-T- P	Credits
1	MA 201	Mathematics – III	3-1-0	4
2	ME 250	Thermal Engineering	3-0-0	3
3	EC 201	Analog Electronics	3-1-0	4
4	EC 203	Networks	3-1-0	4
5		HS and Open Elective – I	3-0-0	3
6	MA 270	Numerical Methods Laboratory	0-0-3	2
7	ME 271	Thermal Engineering Laboratory	0-0-3	2
8	EC 270	Basic Electronics Laboratory	0-0-3	2
9	EC 273	Circuit Simulation Lab	0-0-3	2
		TOTAL		**26**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	MA 202	Mathematics – IV	3-1-0	4
2	EE 202	Electrical Engineering	3-1-0	4
3	EC 202	Digital Electronics	3-0-0	3
4		Professional Elective – I	3-0-0	3
5		HS and Open Elective – II (Management)	3-0-0	3
6	EE 270	Electrical Engineering Laboratory – I	0-0-3	2
7	EC 274	Analog Electronics Laboratory	0-0-3	2

8	EC 276	Digital Electronics Laboratory	0-0-3	2
9	HS 270	Language Laboratory	0-0-3	2
		TOTAL		**25**

FIFTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	EC 301	Microprocessors	3-0-0	3
2	EC 311	Analog Communication Systems	3-1-0	4
3	EC 331	Control System Engineering	3-1-0	4
4	EC 341	Digital Signal Processing	3-1-0	4
5		HS & Open Elective – III	3-0-0	3
6	EC 371	Microprocessors Laboratory	0-0-3	2
7	EC 373	Analog Communication Laboratory	0-0-3	2
8	EC 375	DSP Laboratory	0-0-3	2
9		Elective Laboratory – I	0-0-3	2
		TOTAL		**26**

SIXTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EC 332	Electronic Instrumentation	3-1-0	4
2	EC 334	Instrumentation Devices	3-1-0	4
3		Professional Elective – II	3-1-0	4
4		Professional Elective – III	3-0-0	3
5		HS & Open Elective-IV	3-0-0	3
6	EC 374	Instrumentation Device Lab	0-0-3	2
7	EC 380	Control System Lab	0-0-3	2
8		Elective Lab – II	0-0-3	2
9		Elective Lab – III	0-0-3	2
		TOTAL		**26**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subject	LTP	Credits
1		Professional Elective – IV	3-1-0	4
2		Professional Elective – V	3-1-0	4
3		Professional Elective – VI	3-1-0	4
4		HS & Open Elective – V	3-0-0	3
5		Elective Lab – IV	0-0-3	2
6	EC 491	Research Project – I	0-0-6	4
7	EC 493	Seminar and Technical Writing – I	0-0-3	2
8	EC 495	Short term Industrial / Research Experience	0-0-3	2
		TOTAL		**25**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subject	LTP	Credits
1		Professional Elective – VIII	3-1-0	4
2		Professional Elective – IX	3-0-0	4
3		Professional Elective – X	3-0-0	4
4		HS & Open Elective – IV	3-0-0	3
5		Elective Lab – V	0-0-3	2
6	EC 492	Research Project – II	0-0-9	6
7	EC 494	Seminar and Technical Writing - II	0-0-3	2
8	EC 496	Comprehensive Viva Voce	0-0-0	2
TOTAL				**27**

Curriculum of M. Tech Dual Degree (Spec: Communication & Signal Processing)

[1st - 6th Semester curricula are common with B.Tech. Electronics &Communication Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	EC 615	Mobile Communication	3-1-0	4
2	EC 651	Digital Filter Design	3-1-0	4
3		Professional Electives – III (B.Tech.)	3-0-0	3
4		Professional Electives – IV (B.Tech.)	3-0-0	3
5		Professional Electives – V (B.Tech.)	3-0-0	3
6		Laboratory – I (M.Tech.)	0-0-3	2
7		Laboratory – II (M.Tech.)	0-0-3	2
8	EC 491	Research Project – I	0-0-6	4
9	EC 493	Seminar and Technical Writing – I	0-0-3	2
10	EC 691	Short term industrial/Research Experience	0-0-0	2
TOTAL			**15-2-15**	**29**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	EC 646	Adaptive Signal Processing	3-1-0	4
2	EC 644	Soft Computing	3-1-0	4
3		Professional Elective – VI (B.Tech.)	3-0-0	3
4		Professional Elective – VII (B.Tech.)	3-0-0	3
5		Professional Elective – VIII (B.Tech.)	3-0-0	3
6		Laboratory – III (M.Tech.)	0-0-3	2
7		Laboratory – IV (M.Tech.)	0-0-3	2
8	EC 492	Research Project – II	0-0-9	6
9	EC 494	Seminar and Technical Writing – II	0-0-3	2
TOTAL			**15-2-12**	**29**

NINTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Electives – I (M.Tech.)	3-1-0	4
2		Professional Electives – II (M.Tech.)	3-1-0	4
3		Professional Electives – III (M.Tech.)	3-1-0	4
4	EC 687	Seminar and Technical Writing – III	0-0-3	2
5	EC 693	Research Project – III(Summer)	0-0-0	10
6	EC 694	Research Project – IV	0-0-0	10
TOTAL			**9-3-3**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	EC 688	Seminar and Technical Writing – IV	0-0-3	2
2	EC 692	Comprehensive Viva	0-0-0	4
3	EC 695	Research Project - V	0-0-30	20
TOTAL			**0-0-33**	**26**

Curriculum of M.Tech Dual Degree (Spec: VLSI & Embedded Systems)

[1st - 6th Semester curricula are common with B.Tech. Electronics & Instrumentation Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EC 631	Analytical Instrumentation	3-1-0	4
2	EC 633	PC based Instrumentation	3-1-0	4
3		Professional Elective – III (B.Tech.)	3-0-0	3
4		Professional Elective – IV (B.Tech.)	3-0-0	3
5		Professional Elective – V (B.Tech.)	3-0-0	3
6		Laboratory – I (M.Tech.)	0-0-3	2
7		Laboratory – II (M.Tech.)	0-0-3	2
8	EC 491	Research Project – I	0-0-3	2
9	EC 493	Seminar and Technical Writing – I	0-0-3	2
10	EC 691	Short term Industrial/Research Experience	0-0-0	2
TOTAL			**15-2-12**	**27**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EC 630	Industrial Electronics and Instrumentation	3-1-0	4
2	EC 639	Advanced Process Control	3-1-0	4
3		Professional Elective – VI (B.Tech.)	3-0-0	3
4		Professional Elective – VII (B.Tech.)	3-0-0	3
5		Professional Elective – VIII (B.Tech.)	3-0-0	3
6		Laboratory – III (M.Tech.)	0-0-3	2

7		Laboratory – IV (M.Tech.)	0-0-3	2
8	EC 494	Seminar and Technical Writing – II	0-0-3	2
9	EC 492	Research Project – II	0-0-3	2
TOTAL			**15-2-12**	**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1		Professional Elective – I (M.Tech.)	3-1-0	4
2		Professional Elective – II (M.Tech.)	3-1-0	4
3		Professional Elective – III (M.Tech.)	3-1-0	4
4	EC 687	Seminar and Technical Writing – III	0-0-3	2
5	EC 693	Research Project – III(Summer)	0-0-0	10
6	EC 694	Research Project – IV	0-0-0	10
TOTAL			**9-3-3**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EC 688	Seminar and Technical Writing – IV	0-0-3	2
2	EC 692	Comprehensive Viva	0-0-0	4
3	EC 695	Research Project – V	0-0-30	20
TOTAL			**0-0-33**	**26**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subjects	L-T-P	Credits	Offered to
1	EC 204	Semiconductor Devices	3-0-0	3	#
2	EC 232	Electrical and Electronic Measurement	3-0-0	3	#
3	EC 312	Electromagnetic Theory	3-0-0	3	#
4	EC 314	Digital Communication	3-0-0	3	#
5	EC 322	Embedded Systems	3-0-0	3	#
6	EC 332	Electronic Instrumentation	3-1-0	4	#
7	EC 390	Special Laboratory in Electronics & Comm Engg – I	0-0-3	2	#
8	EC 391	Special Topic in Electronics & Instrumentation Engg – I		3/4	#
9	EC 392	Special Topic in Electronics & Instrumentation Engg – II		3/4	#
10	EC 393	Special Laboratory in Electronics & Instrumentation Engg – I	0-0-3	2	#
11	EC 394	Special Laboratory in Electronics & Instrumentation Engg – II	0-0-3	2	#
12	EC 395	Engineering Product Development Project – I	0-0-6	4	#
13	EC 396	Engineering Product Development Project – II	0-0-6	4	#
14	EC 397	Special Topic in Electronics & Communication Engg – I		3/4	#
15	EC 398	Special Topic in Electronics & Communication Engg – II		3/4	#

16	EC 399	Special Laboratory in Electronics & Communication Engg – II	0-0-3	2	#
17	EC 410	Antenna Engineering	3-0-0	3	#
18	EC 411	Coding Theory and Secured Communication	3-0-0	3	#
19	EC 412	Antenna Analysis and Synthesis	3-1-0	4	#
20	EC 413	Optical Communication	3-0-0	3	#
21	EC 414	Information Theory and Coding	3-0-0	3	#
22	EC 415	Mobile Communication	3-0-0	3	#
23	EC 416	Microwave Engineering	3-0-0	3	#
24	EC 417	Satellite Communication	3-1-0	4	#
25	EC 419	Computer Communication Network	3-1-0	4	#
26	EC 421	Digital VLSI Design	3-1-0	4	#
27	EC 423	HDL and High Level VLSI	3-1-0	4	@
28	EC 424	Embedded Computing System	3-1-0	4	#
29	EC 426	Low Power VLSI Design	3-1-0	4	$
30	EC 427	VLSI Technology	3-1-0	4	$
31	EC 430	Industrial Electronics & Instrumentation	3-1-0	4	@
32	EC 433	Process Control & Instrumentation	3-1-0	4	#
33	EC 436	Biomedical Instrumentation	3-0-0	3	#
34	EC 438	Virtual Instrumentation	3-0-0	3	$
35	EC 439	Advanced Process Control	3-1-0	4	@
36	EC 442	Advanced Techniques in Digital Signal Processing	3-1-0	4	#
37	EC 443	Digital Image Processing	3-0-0	3	#
38	EC 444	Soft Computing	3-1-0	4	#
39	EC 446	Adaptive Signal Processing	3-1-0	4	#
40	EC 448	Evolutionary Computing Techniques	3-1-0	4	#
41	EC 619	Computer Communication Networks	3-1-0	4	$
42	EC 620	MCS VLSI Systems	3-1-0	4	$
43	EC 623	HDL and High level VLSI	3-1-0	4	$
44	EC 640	Pattern Recognition Application	3-1-0	4	$
45	EC 644	Soft Computing	3-0-0	3	$
46	EC 653	Image Processing & Computer Vision	3-1-0	4	$
47	EC 655	Transformation Domain Signal Processing	3-1-0	4	$
48	EE 665	Digital Speech Processing	3-1-0	4	$

*Notes: # (B.Tech. and all dual degrees), $(only for dual degree courses), @ (only for B.Tech courses)

PROFESSIONAL ELECTIVES FROM OTHER DEPARTMENTS

Sl. No	Sub. Code	Subject	L-T- P	Credits
1.	EE 336	Advanced Instrumentation	3-0-0	3
2.	EE 355	Computer Organization and Operating Systems	3-0-0	3
3.	EE 426	Fuzzy Modeling and Control	3-0-0	3
4.	EE 427	Artificial Neural Network	3-0-0	3
5.	EE 445	Data Communication and Networking	3-0-0	3

LIST OF ELECTIVE LAB COURSES

Sl. No	Sub. Code	Subject	L-T- P	Credits	Offered to
1	CS 471	Networks Laboratory	0-0-3	2	@
2	EC 370	Embedded Systems Laboratory	0-0-3	2	#
3	EC 374	Instrumentation Device Laboratory	0-0-3	2	#
4	EC 377	Electronics Design Laboratory	0-0-3	2	#
5	EC 378	Microwave Laboratory	0-0-3	2	#
6	EC 379	PCB Design Laboratory	0-0-3	2	#
7	EC 380	Control System Laboratory	0-0-3	2	#
8	EC 471	Optical communication Laboratory	0-0-3	2	#
9	EC 472	Image Processing Laboratory	0-0-3	2	#
10	EC 473	High Level VLSI Laboratory	0-0-3	2	#
11	EC 474	DSP Processor Laboratory	0-0-3	2	#
12	EC 475	VLSI Laboratory	0-0-3	2	#
13	EC 476	Biomedical Laboratory	0-0-3	2	#
14	EC 477	Mobile Communication Laboratory	0-0-3	2	#
15	EC 478	Antenna Design Laboratory	0-0-3	2	#
16	EC 479	Process Control Laboratory	0-0-3	2	#
17	EC 670	Mobile Communication Lab	0-0-3	2	$
18	EC 671	Digital Signal Processing Laboratory	0-0-3	2	$
19	EC 674	Soft Computing Laboratory	0-0-3	2	$
20	EC 675	High Level VLSI Design Laboratory	0-0-3	2	$
21	EC 677	VLSI Design Laboratory	0-0-3	2	$
22	EC 678	Embedded Computing System Lab	0-0-3	2	$
23	EC 773	Advanced Instrumentation Laboratory	0-0-3	2	$
24	EC 774	Digital Image Processing Laboratory	0-0-3	2	$
25	EC 776	Advanced Process Control Laboratory	0-0-3	2	$
26	EC 777	Digital Filter Design Lab	0-0-3	2	$
27	EC 778	Adaptive Signal Processing Laboratory	0-0-3	2	$

****Notes:*** *# (B.Tech. and all dual degree courses), $(only for dual degree courses), @ (only for B.Tech courses)*

COURSES OFFERED AS OPEN ELECTIVES

(Normally not offered to students of Electronics & Communication Engineering)

Sl. No	Sub. Code	Subject	L-T-P	Credits	Non Eligible Branches
1	EC 200	Fundamentals of Communication Systems	3-0-0	3	EE, CS
2	EC 300	Microprocessor	3-0-0	3	EE, CS
3	EC 320	Embedded Systems	3-0-0	3	EE, CS
4	EC 330	Process Control and Instrumentation	3-0-0	3	-
5	EC 340	Fundamentals of Digital Signal Processing	3-0-0	3	EE, CS
6	EC 432	Biomedical Instrumentation	3-0-0	3	-
7	EC 440	Soft Computing Techniques	3-0-0	3	-

8	EC 450	Fundamentals of Digital Image Processing	3-0-0	3	-

SUMMARY OF COURSES

Sub Discipline:	**Circuit and Systems**		
EC 100	Basic Electronics Engineering	3-1-0	4
EC 200	Fundamentals of Communication Systems	3-0-0	3
EC 201	Analog Electronics	3-1-0	4
EC 202	Digital Electronics	3-0-0	3
EC 203	Networks	3-1-0	4
EC 204	Semiconductor Devices	3-0-0	3
EC 300	Microprocessors	3-0-0	3
EC 301	Microprocessors	3-0-0	3

Sub Discipline:	**Communications**		
EC 311	Analog Communication Systems	3-1-0	4
EC 312	Electromagnetic Theory	3-0-0	3
EC 314	Digital Communication	3-0-0	3
EC 316	Microwave Engineering	3-0-0	3
EC 410	Antenna Engineering	3-0-0	3
EC 411	Coding Theory and Secured Communication	3-0-0	3
EC 412	Antenna Analysis and Synthesis	3-1-0	4
EC 413	Optical Communication	3-0-0	3
EC 414	Information Theory and Coding	3-0-0	3
EC 415	Mobile Communication	3-0-0	3
EC 416	Microwave Engineering	3-0-0	3
EC 417	Satellite Communication	3-1-0	4
EC 419	Computer Communication Network	3-1-0	4
EC 611	Digital Communication	3-1-0	4
EC 615	Mobile Communication	3-1-0	4
EC 619	Computer Communication Network	3-1-0	4

Sub Discipline:	**VLSI and Embedded Systems**		
EC 320	Embedded Systems	3-0-0	3
EC 322	Embedded Systems	3-0-0	3
EC 421	Digital VLSI Design	3-1-0	4
EC 423	HDL and High Level VLSI	3-1-0	4
EC 424	Embedded Computing System	3-1-0	4
EC 426	Low Power VLSI Design	3-1-0	4
EC 427	VLSI Technology	3-1-0	4
EC 620	MCS VLSI Systems	3-1-0	4
EC 623	HDL and High Level VLSI	3-1-0	4

Sub Discipline:	Instrumentation Systems		
EC 232	Electrical and Electronic Measurement	3-0-0	3
EC 330	Process Control and Instrumentation	3-0-0	3
EC 331	Control System Engineering	3-1-0	4
EC 332	Electronic Instrumentation	3-1-0	4
EC 334	Instrumentation Devices	3-1-0	4
EC 336	Industrial Instrumentation	3-0-0	3
EC 338	Virtual Instrumentation	3-1-0	4
EC 430	Industrial Electronics and Instrumentation	3-1-0	4
EC 431	PC based Instrumentation	3-0-0	3
EC 432	Biomedical Instrumentation	3-0-0	3
EC 433	Process Control and Instrumentation	3-1-0	4
EC 434	Analytical Instrumentation	3-0-0	4
EC 436	Biomedical Instrumentation	3-0-0	3
EC 437	Radar Engineering	3-0-0	3
EC 438	Virtual Instrumentation	3-0-0	3
EC 439	Advanced Process Control	3-1-0	4
EC 630	Industrial Electronics and Instrumentation	3-1-0	4
EC 631	Analytical Instrumentation	3-1-0	4
EC 633	PC based Instrumentation	3-1-0	4
EC 639	Advanced Process Control	3-1-0	4

Sub Discipline:	Signal Processing		
EC 340	Fundamentals of Digital Signal Processing	3-0-0	3
EC 341	Digital Signal Processing	3-1-0	4
EC 440	Soft Computing Techniques	3-0-0	3
EC 442	Advanced Techniques in Digital Signal Processing	3-1-0	4
EC 443	Digital Image Processing	3-0-0	3
EC 444	Soft Computing	3-1-0	4
EC 446	Adaptive Signal Processing	3-1-0	4
EC 448	Evolutionary Computing Techniques	3-1-0	4
EC 450	Fundamentals of Digital Image Processing	3-0-0	3
EC 640	Pattern Recognition Application	3-1-0	4
EC 641	Digital Signal Processing	3-1-0	4
EC 642	Advanced Techniques in DSP	3-1-0	4
EC 644	Soft Computing	3-1-0	4
EC 646	Adaptive Signal Processing	3-1-0	4
EC651	Digital Filter Design	3-1-0	4
EC 653	Image Processing & Computer Vision	3-1-0	4
EC 655	Transform Domain Signal Processing	3-1-0	4

Sub Discipline:	Laboratory Courses		
EC 270	Basic Electronics Laboratory	0-0-3	2
EC 273	Circuit Simulation Laboratory	0-0-3	2
EC 274	Analog Electronics Laboratory	0-0-3	2
EC 276	Digital Electronics Laboratory	0-0-3	2
EC 370	Embedded Systems Laboratory	0-0-3	2
EC 371	Microprocessors Laboratory	0-0-3	2
EC 372	Digital Communication Laboratory	0-0-3	2
EC 373	Analog Communication Laboratory	0-0-3	2
EC 374	Instrumentation Device Laboratory	0-0-3	2
EC 375	DSP Laboratory	0-0-3	2
EC 377	Electronics Design Laboratory	0-0-3	2
EC 378	Microwave Laboratory	0-0-3	2
EC 379	PCB Design Laboratory	0-0-3	2
EC 380	Control System Laboratory	0-0-3	2
EC 382	Communication system Design Laboratory	0-0-3	2
EC 471	Optical communication Laboratory	0-0-3	2
EC 472	Image Processing Laboratory	0-0-3	2
EC 473	High Level VLSI Laboratory	0-0-3	2
EC 474	DSP Processor Laboratory	0-0-3	2
EC 475	VLSI Laboratory	0-0-3	2
EC 476	Biomedical Laboratory	0-0-3	2
EC 477	Mobile Communication Laboratory	0-0-3	2
EC 478	Antenna Design Laboratory	0-0-3	2
EC 479	Process Control Laboratory	0-0-3	2
EC 670	Mobile Communication Laboratory	0-0-3	2
EC 671	Digital Signal Processing Laboratory	0-0-3	2
EC 674	Soft Computing Laboratory	0-0-3	2
EC 675	High Level VLSI Design Laboratory	0-0-3	2
EC 677	VLSI Design Laboratory	0-0-3	2
EC 678	Embedded Computing System Laboratory	0-0-3	2
EC 773	Advanced Instrumentation Laboratory	0-0-3	2
EC 774	Digital Image Processing Laboratory	0-0-3	2
EC 776	Advanced Process Control Laboratory	0-0-3	2
EC 777	Digital Filter Design Lab	0-0-3	2
EC 778	Adaptive Signal Processing Laboratory	0-0-3	2

Sub Discipline:	Project, Seminar and Special Courses		
EC 390	Special Laboratory in Electronics & Communication Engg – I	0-0-3	2
EC 391	Special Topic in Electronics & Instrumentation Engg – I		3/4
EC 392	Special Topic in Electronics & Instrumentation Engg – II		3/4
EC 393	Special Laboratory in Electronics & Instrumentation Engg – I	0-0-3	2

EC 394	Special Laboratory in Electronics & Instrumentation Engg – II	0-0-3	2
EC 395	Engineering Product Development Project – I	0-0-6	4
EC 396	Engineering Product Development Project – II	0-0-6	4
EC 397	Special Topic in Electronics & Communication Engg - I		3/4
EC 398	Special Topic in Electronics & Communication Engg – II		3/4
EC 399	Special Laboratory in Electronics & Communication Engg - II	0-0-3	2
EC 491	Research Project – I	0-0-3	2
EC 492	Research Project – II	0-0-3	2
EC 493	Seminar and Technical Writing – I	0-0-3	2
EC 494	Seminar and Technical Writing – II	0-0-3	2
EC 495	Short Term Industrial/Research Experience	0-0-3	2
EC 496	Comprehensive Viva Voce	0-0-0	2
EC 687	Seminar and Technical Writing – III	0-0-3	2
EC 688	Seminar and Technical Writing – IV	0-0-3	2
EC 691	Short Term Industrial/Research Experience	0-0-0	2
EC 692	Comprehensive Viva	0-0-0	4
EC 693	Research Project – III(Summer)	0-0-0	10
EC 694	Research Project – IV	0-0-0	10
EC 695	Research Project – V	0-0-30	20

DEPARTMENT OF ELECTRICAL ENGINEERING

Curriculum of B.Tech (Electrical Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub.Code	Subject		L-T-P	Credits
1	MA 101	Mathematics – I		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 Engineering	OR	3-1-0	4
	EC 100	Basic Electronics Engineering			
5	CE 100	Engineering Mechanics	OR	3-1-0	4
	CE 130	Environment 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	Subject		L-T-P	Credits
1	MA 102	Mathematics – II		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithm		3-1-0	4
4	EC 100	Basic Electronics Engineering	OR	3-1-0	4
	EE 100	Basic Electrical Engineering			
5	CE 130	Environment 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 – II		0-0-3	2
		TOTAL			**30**

THIRD SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 203	Electrical Machines - I	3-1-0	4
2	EE 241	Network Theory	3-1-0	4
3	EE 243	Analog Electronics	3-1-0	4

4	MA 201	Mathematics – III		3-1-0	4
5		HS & Open Elective – I		3-0-0	3
6	EE 271	Network Laboratory		0-0-3	2
7	EC 270	Basic Electronics Laboratory		0-0-3	2
8	EE 277	Electrical Machines Laboratory – I		0-0-3	2
9	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
TOTAL					**27**

FOURTH SEMESTER

Sl. No	Sub. Code	Subject		L-T-P	Credits
1	EE 204	Electro Magnetic Fields		3-1-0	4
2	EE 240	Measurement and Instrumentation		3-1-0	4
3	EE 242	Digital Electronics and Microprocessor		3-1-0	4
4	MA 202	Mathematics – IV		3-1-0	4
5		HS & Open Elective – II		3-0-0	3
6	EE 272	Measurement Laboratory		0-0-3	2
7	EE 274	Electronics Laboratory		0-0-3	2
8	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
9	ME 272	Mechanical Engg. Laboratory		0-0-3	2
TOTAL					**27**

FIFTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 301	Electrical Machines – II	3-1-0	4
2	EE 311	Transmission & Distribution of Electric Power	3-1-0	4
3	EE 341	Embedded Systems	3-1-0	4
4		Professional Elective – I	3-0-0	3
5		HS & Open Elective – III	3-0-0	3
6	EE 371	Communication System Laboratory	0-0-3	2
7	EE 373	Electrical Machines Laboratory – II	0-0-3	2
8	EE 375	Embedded Systems Laboratory	0-0-3	2
9	EE 377	Electrical Machine Design	0-0-3	2
TOTAL				**26**

SIXTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 322	Control System – I	3-1-0	4
2	EE 312	Switch Gear & Protective Devices	3-1-0	4
3	EE 324	Power Electronics	3-1-0	4
4		Professional Elective – II	3-0-0	3
5		HS & Open Elective – IV	3-0-0	3

6	EE 370	Power Electronics Laboratory	0-0-3	2
7	EE 372	Control System Laboratory	0-0-3	2
8	EE 374	Electrical Systems Simulation Laboratory	0-0-3	2
9	EE 376	Power Systems Laboratory	0-0-3	2
		TOTAL		**26**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1		Professional Elective – III		3/4
2		Professional Elective – IV		3/4
3		Professional Elective – V		3/4
4		HS & Open Elective – V	3-0-0	3
5	EE 471	Electric Drives Laboratory	0-0-3	2
6	EE 491	Research Project – I	0-0-6	4
7	EE 493	Seminar and Technical Writing – I	0-0-3	2
8	EE 495	Short Term Industrial / Research Experience	0-0-3	2
		TOTAL		**22/25**

EIGHT SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1		Professional Elective – VI		3/4
2		Professional Elective – VII		3/4
3		Professional Elective – VIII		3/4
4		HS & Open Elective – VI	3-0-0	3
5	EE 472	Control & Electrical System Design	0-0-3	2
6	EE 492	Research Project – II	0-0-9	6
7	EE 494	Seminar and Technical Writing – II	0-0-3	2
8	EE 496	Comprehensive Viva-Voce	0-0-0	2
		TOTAL		**24/27**

Curriculum of M.Tech Dual Degree (Specialization: Control & Automation)

[1st - 6th Semester curricula are common with B.Tech. Electrical Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 625	Systems and Control Theory	3-1-0	4
2	EE 629	Digital Control	3-1-0	4
3		Professional Elective – III (B.Tech.)	3-1-0	4
4		Professional Elective – IV (B.Tech.)	3-1-0	4
5		Professional Elective – V (B.Tech.)	3-1-0	4
6	EE 673	Modeling and Simulation Laboratory	0-0-3	2
7	EE 679	Control Systems Laboratory	0-0-3	2
8	EE 491	Research Project – I	0-0-3	2
9	EE 493	Seminar and Technical Writing – I	0-0-3	2

10	EE 691	Short Term Industrial/Research Experience	0-0-0	2
		TOTAL	**15-5-12**	**30**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 628	Industrial Process Automation	3-1-0	4
2	EE 636	System Identification and Adaptive Control	3-1-0	4
3		Professional Elective – VI (B.Tech.)	3-0-0	3
4		Professional Elective – VII (B.Tech.)	3-0-0	3
5		Professional Elective – VIII (B.Tech.)	3-0-0	3
6	EE 670	Instrumentation Laboratory	0-0-3	2
7	EE 674	Embedded Systems Laboratory	0-0-3	2
8	EE 492	Research Project – II	0-0-3	2
9	EE 494	Seminar & Technical Writing – II	0-0-3	2
		TOTAL	**15-2-12**	**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1		Professional Elective –IX (M.Tech.)	3-1-0	4
2		Professional Elective – X (M.Tech.)	3-1-0	4
3		Professional Elective – XI (M.Tech.)	3-1-0	4
4	EE 687	Seminar & Technical Writing – III	0-0-3	2
6	EE 693	Research Project – III	0-0-0	10
7	EE 694	Research Project – IV	0-0-0	10
		TOTAL	**9-3-3**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 688	Seminar & Technical Writing – IV	0-0-3	2
2	EE 692	Comprehensive Viva-Voce	0-0-0	4
3	EE 695	Research Project Work – V	0-0-30	20
		TOTAL	**0-0-33**	**26**

Curriculum of M.Tech Dual Degree (Specialization: Electronic Systems & Communication)

[1st Semester to 6th Semester is common to B.Tech. Electrical Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 641	Digital Communication	3-1-0	4
2	EE 643	Microwave & Antenna Systems	3-1-0	4
3		Professional Elective – III (B.Tech.)	3-1-0	4
4		Professional Elective – IV (B.Tech.)	3-1-0	4
5		Professional Elective – V (B.Tech.)	3-1-0	4
8	EE 491	Research Project – I	0-0-3	2

9	EE 493	Seminar & Technical Writing – I	0-0-3	2
6	EE 671	Microwave & Antenna Laboratory	0-0-3	2
7	EE 673	Modeling & Simulation Laboratory	0-0-3	2
8	EE 691	Short Term Industrial/Research Experience	0-0-0	2
		TOTAL	**15-5-12**	**30**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 642	Wireless Communication	3-1-0	4
2	EE 654	Satellite Communication	3-1-0	4
3		Professional Elective – VI (B.Tech.)	3-0-0	3
4		Professional Elective – VII (B.Tech.)	3-0-0	3
5		Professional Elective – VIII (B.Tech.)	3-0-0	3
9	EE 492	Research Project – II	0-0-3	2
8	EE 494	Seminar and Technical Writing – II	0-0-3	2
6	EE 672	Advanced Communication Laboratory	0-0-3	2
7	EE 674	Embedded Systems Laboratory	0-0-3	2
		TOTAL	**15-2-12**	**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1		Professional Elective –IX (M.Tech.)	3-1-0	4
2		Professional Elective – X (M.Tech.)	3-1-0	4
3		Professional Elective – XI (M.Tech.)	3-1-0	4
4	EE 687	Seminar & Technical Writing – III	0-0-3	2
5	EE 693	Research Project – III(Summer)	0-0-0	10
6	EE 694	Research Project Work – IV	0-0-0	10
		TOTAL	**9-3-3**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 688	Seminar and Technical Writing – IV	0-0-3	2
2	EE 692	Comprehensive Viva	0-0-0	4
3	EE 695	Research Project – V	0-0-30	20
			TOTAL	**26**

Curriculum of M.Tech Dual Degree (Specialization: Power Control & Drives)

[1st - 6th Semester curricula are common with B.Tech. Electrial Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 611	Machine Analysis	3-1-0	4
2	EE 621	Power Electronic Converters & Machine Drives	3-1-0	4
3		Professional Elective – III (B.Tech.)	3-1-0	4

4		Professional Elective – IV (B.Tech.)	3-1-0	4
5		Professional Elective – V (B.Tech.)	3-1-0	4
6	EE 675	Power Electronics and Drives Laboratory – I	0-0-3	2
7	EE 677	Machines and Control Laboratory	0-0-3	2
8	EE 491	Research Project – I	0-0-3	2
9	EE 493	Seminar and Technical Writing – I	0-0-3	2
10	EE 691	Short Term Industrial/Research Experience	0-0-0	2
		TOTAL	**15-3-12**	**28**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 612	Advanced Machine Drives	3-1-0	4
2	EE 622	Advanced Power Electronic Converters	3-1-0	4
3		Professional Elective – VI (B.Tech.)	3-0-0	3
4		Professional Elective – VII (B.Tech.)	3-0-0	3
5		Professional Elective – VIII (B.Tech.)	3-0-0	3
6	EE 676	Power Electronics and Drives Lab – II	0-0-3	2
7	EE 678	Power Electronics and Drives Simulation Lab	0-0-3	2
8	EE 492	Research Project – II	0-0-3	2
9	EE 494	Seminar and Technical Writing – II	0-0-3	2
		TOTAL	**15-2-12**	**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1		Professional Elective – IX (M.Tech.)	3-1-0	4
2		Professional Elective – X (M.Tech.)	3-1-0	4
3		Professional Elective – XI (M.Tech.)	3-1-0	4
4	EE 687	Seminar & Technical Writing – III	0-0-3	2
5	EE 693	Research Project – III(Summer)	0-0-0	10
6	EE 694	Research Project – IV	0-0-0	10
		TOTAL	**9-3-18**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EE 688	Seminar & Technical Writing – IV	0-0-3	2
2	EE 692	Comprehensive Viva –Voce	0-0-0	4
3	EE 695	Research Project – V	0-0-30	20
		TOTAL	**0-0-33**	**26**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subjects	L-T-P	Credits	Offered to
1	EE 336	Advanced Instrumentation	3-0-0	3	@
2	EE 345	Communication Systems Principles	3-0-0	3	@

3	EE 355	Computer Organization & Operating Systems	3-0-0	3	@
4	EE 356	Digital Signal Processing	3-0-0	3	@
5	EE 391	Special Topic in Electrical Engineering – I		3/4	@
6	EE 392	Special Topic in Electrical Engineering – II		3/4	@
7	EE 393	Special Laboratory in Electrical Engineering – I	0-0-3	2	@
8	EE 394	Special Laboratory in Electrical Engineering – II	0-0-3	2	@
9	EE 395	Engineering Product Development Project – I	0-0-6	4	@
10	EE 396	Engineering Product Development Project – II	0-0-6	4	@
11	EE 401	Power System Operation & Control	3-1-0	4	#
12	EE 404	Renewable Energy Systems	3-0-0	3	#
13	EE 405	Utilization of Electrical Energy & Drives	3-1-0	4	#
14	EE 406	High Voltage DC Transmission	3-0-0	3	#
15	EE 407	Electric Drives	3-1-0	4	#
16	EE 408	Electromagnetic Theory & Application	3-0-0	3	@
17	EE 416	Power System Transients	3-0-0	3	#
18	EE 417	High Voltage Engineering	3-1-0	4	#
19	EE 425	Control System – II	3-1-0	4	#
20	EE 426	Fuzzy Modeling & Control	3-0-0	3	#
21	EE 427	Soft Computing	3-1-0	4	#
22	EE 429	Advanced Control Theory	3-0-0	3	@
23	EE 436	Adaptive Control and System Identification	3-0-0	3	#
24	EE 438	Industrial Automation & Control	3-0-0	3	#
25	EE 445	Data Communication & Networks	3-1-0	4	#
26	EE 454	Digital Communication	3-0-0	3	#
27	EE 455	Digital Signal Processing	3-1-0	4	$
28	EE 456	Robotics and Computer Vision	3-0-0	3	#
29	EE 604	Flexible AC Transmission Systems	3-1-0	4	$
30	EE 605	Power Plant Control and Instrumentation	3-1-0	4	$
31	EE 606	Transient in Power Systems	3-1-0	4	$
32	EE 607	Extra High Voltage Transmission	3-1-0	4	$
33	EE 615	Power System Dynamics	3-1-0	4	$
34	EE 616	Electrical Energy Systems	3-1-0	4	$
35	EE 621	Power Electronics Converters and Machine Drives	3-1-0	4	$
36	EE 623	Control of Electric Drives	3-1-0	4	$
37	EE 624	Distributed Control & Communication Networks	3-1-0	4	$
38	EE 625	Systems and Control Theory	3-1-0	4	$
39	EE 626	Digital Control	3-1-0	4	$
40	EE 627	Optimal Control	3-1-0	4	$
41	EE 629	Digital Control	3-1-0	4	$
42	EE 630	Robust Control.	3-1-0	4	$
43	EE 631	Industrial Electronics	3-1-0	4	$
44	EE 633	Power Plant Control and Instrumentation	3-1-0	4	$

45	EE 634	Robotics and Automation	3-1-0	4	$
46	EE 636	System Identification and Adaptive Control	3-1-0	4	$
47	EE 637	Soft Computing Techniques	3-1-0	4	$
48	EE 638	Intelligent Control	3-1-0	4	$
49	EE 641	Digital Communication	3-1-0	4	$
50	EE 643	Microwave & Antenna Systems	3-1-0	4	$
51	EE 645	Adaptive Signal Processing	3-1-0	4	$
52	EE 646	Estimation of Signal and Systems	3-1-0	4	$
53	EE 647	Wireless Networks & Protocols	3-1-0	4	$
54	EE 649	Wireless Sensor Networks	3-1-0	4	$
55	EE 651	Digital Speech Processing	3-1-0	4	$
56	EE 652	Ad-Hoc Networks	3-1-0	4	$
57	EE 653	Digital Image Processing	3-1-0	4	$
58	EE 654	Satellite Communication	3-1-0	4	$
59	EE 655	VLSI Signal Processing	3-1-0	4	$
60	EE 657	Optical communication	3-1-0	4	$
61	EE 659	Digital VLSI Design	3-1-0	4	$
62	EE 661	Advanced Signal Processing	3-1-0	4	$
63	EE 663	Microprocessor and Microcontroller Systems	3-1-0	4	$
64	EE 664	Embedded Computing Systems	3-1-0	4	$
65	EE 667	Microelectronic Devices and Circuits	3-1-0	4	$
66	EE 668	Instrumentation and Sensors	3-1-0	4	$
67	EE 681	Special Topics in Electrical Engineering – I		3/4	$
68	EE 682	Special Topics in Electrical Engineering – II		3/4	$
69	EE 683	Special Laboratory in Electrical Engineering – I	0-0-3	2	$
70	EE 684	Special Laboratory in Electrical Engineering –II	0-0-3	2	$

***Notes:** # (B.Tech. and all dual degree courses), $(only for dual degree courses), @ (only for B.Tech courses)*

PROFESSIONAL ELECTIVES OFFERED BY OTHER DEPARTMENTS

Sl. No	Sub. Code	Subject	L-T-P	Credits	Offered to
1	BM 223	Bioelectricity	3-1-0	4	$
2	BM 388	Biosensors and Diagnostics	3-0-0	3	$
3	BM 433	Medical Embedded system	3-0-0	3	#
4	CE 316	Advanced Mechanics of Solids	3-1-0	4	#
5	CE 318	Finite Element Method	3-1-0	4	#
6	CH 224	Polymer Science and Technology	3-0-0	3	@
7	CH 331	Process Instrumentation	3-0-0	3	$
8	CR 335	Instrumental Characterization	3-1-0	4	@
9	CR 346	Nano ceramics	3-0-0	3	@
10	CR 433	Sensor Technology	3-0-0	3	#
11	CR 441	Electrical and Magnetic Ceramics	3-1-0	4	@
12	CS 213	Principles of Programming Languages	3-1-0	4	#

13	CS 315	Optimization Techniques	3-1-0	4	#
14	CS 335	Computer Graphics & Multimedia	3-1-0	4	#
15	CS 425	Network Security	3-1-0	4	$
16	CS 427	Network Security	3-1-0	4	@
17	CS 439	Computer Vision	3-0-0	3	#
18	CS 633	Distributed Operating Systems	3-1-0	4	$
19	CS 634	Bioinformatics	3-1-0	4	$
20	CS 638	Pattern Recognition	3-1-0	4	$
21	CS 645	Parallel Algorithms	3-1-0	4	$
22	CS 649	VLSI System Design	3-1-0	4	$
23	EC 336	Industrial Instrumentation	3-1-0	4	#
24	EC 433	Process Control Instrumentation	3-0-0	3	#
25	EC 436	Biomedical Instrumentation	3-0-0	3	@
26	EC 623	HDL and High Level VLSI	3-1-0	4	$
27	EC 640	Pattern Recognition Application	3-1-0	4	$
28	MA 512	Fourier Analysis	3-1-0	4	#
29	MA 522	Operation Research	3-1-0	4	#
30	MA 523	Discrete Mathematics	3-1-0	4	#
31	MA 524	Statistical Methods	3-1-0	4	#
32	MA 527	Fractals	3-1-0	4	#
33	MA 551	Numerical Analysis	3-1-0	4	#
34	MA 552	Fuzzy logic and Set Theory	3-1-0	4	#
35	MA 553	Optimization Techniques	3-1-0	4	#
36	MA 554	Graph Theory	3-1-0	4	#
37	ME 414	Mechatronics	3-0-0	3	#
38	ME 416	Robotics	3-0-0	3	#
39	ME 418	Material Handling	3-0-0	3	#
40	ME 430	Industrial Management	3-0-0	3	#
41	ME 451	Power Plant Engineering	3-0-0	3	#
42	MM 359	Engineering Polymers and Composites	3-1-0	4	#
43	MN 325	Ground Control Instrumentation	3-1-0	4	#
44	PH 554	Physics of Thin Film Technology	3-1-0	4	@
45	PH 645	Non-linear dynamics, Chaos and its recent applications	3-1-0	4	#
46	PH 646	Synchronization and its recent applications in Chaotic systems	3-1-0	4	#
47	PH 651	Dielectric & Magnetic Properties of Materials	3-1-0	4	#
48	PH 652	Electronics Ceramics	3-1-0	4	#
49	PH 652	Electronics Ceramics	3-1-0	4	
50	PH 654	Physics of Material Synthesis and Characterization	3-1-0	4	#
51	PH 655	Physics of Thin film Technology	3-1-0	4	$
52	PH 663	Nano Structure of Materials			#

***Notes:** *# (B.Tech. and all dual degree courses), $(only for dual degree courses), @ (only for B.Tech courses)*

COURSES OFFERED AS OPEN ELECTIVE

(Normally not offered to students of Electrical Engineering)

Sl. No	Sub. Code	Subject	L-T-P	Credits	Non Eligible Branches
1.	EE 208	Advanced Electrical Engineering	3-0-0	3	-
2.	EE 209	Network Analysis	3-0-0	3	CE, CR, MN, ME, MM, CH
3.	EE 308	Utilization of Electrical Energy	3-0-0	3	CE, CR, BM
4.	EE 309	Power Generation Systems	3-0-0	3	CE, CR, MN, MM, CS
5.	EE 428	Electrical Drives Concepts & Applications	3-0-0	3	CE, CR, MN, MM, CH
6.	EE 431	Control System Engineering	3-0-0	3	CE, CR

SUMMARY OF COURSES (M.Tech Dual Degree)

Sub Discipline:	Power System		
EE 101	Basic Electrical Technology	3-1-0	4
EE 204	Electro Magnetic Fields	3-1-0	4
EE 208	Electrical Technology & Applications	3-0-0	3
EE 209	Network Analysis	3-0-0	3
EE 306	Electromagnetic Fields	3-0-0	3
EE 308	Utilization of Electrical Energy	3-0-0	3
EE 309	Power Generation Systems	3-0-0	3
EE 311	Transmission & Distribution of Electric Power	3-1-0	4
EE 312	Switch Gear & Protective Devices	3-1-0	4
EE 401	Power System Operation & Control	3-1-0	4
EE 404	Renewable Energy Systems	3-0-0	3
EE 405	Utilization of Electrical Energy & Drives	3-1-0	4
EE 406	High Voltage DC Transmission	3-0-0	3
EE 416	Power System Transients	3-0-0	3
EE 417	High Voltage Engineering	3-1-0	4
EE 604	Flexible AC Transmission Systems	3-1-0	4
EE 605	Power Plant Control and Instrumentation	3-1-0	4
EE 606	Transient in Power Systems	3-1-0	4
EE 607	Extra High Voltage Transmission	3-1-0	4
EE 615	Power System Dynamics	3-1-0	4
EE 616	Electrical Energy Systems	3-1-0	4
EE 633	Power Plant Control and Instrumentation	3-1-0	4

Sub Discipline:	Power Electronics, Machines and Drives		
EE 203	Electrical Machines - I	3-1-0	4
EE 301	Electrical Machines - II	3-1-0	4
EE 324	Electric Devices	3-1-0	4

EE 407	Renewable Energy Systems	3-1-0	4
EE 428	Electrical Drives	3-1-0	4
EE 611	Machine Analysis	3-1-0	4
EE 612	Advanced Machine Drives	3-1-0	4
EE 621	Power Electronic Converters & Machine Drives	3-1-0	4
EE 622	Advanced Power Electronic Converters	3-1-0	4
EE 631	Industrial Electronics	3-1-0	4

Sub Discipline:	**Control and Automation**		
EE 322	Control System – I	3-1-0	4
EE 425	Control System – II	3-1-0	4
EE 426	Fuzzy Modeling & Control	3-0-0	3
EE 427	Soft Computing	3-1-0	4
EE 436	Adaptive Control and System Identification	3-0-0	3
EE 438	Industrial Automation & Control	3-0-0	3
EE 625	Systems and Control Theory	3-1-0	4
EE 628	Industrial Process Automation	3-1-0	4
EE 629	Digital Control	3-1-0	4
EE 630	Robust Control.	3-1-0	4
EE 634	Robotics and Automation	3-1-0	4
EE 636	System Identification and Adaptive Control	3-1-0	4
EE 637	Soft Computing Techniques	3-1-0	4
EE 638	Intelligent Control	3-1-0	4
EE 646	Estimation of Signal and Systems	3-1-0	4

Sub Discipline:	**Communication and Signal Processing**		
EE 240	Measurement and Instrumentation	3-1-0	4
EE 241	Network Theory	3-1-0	4
EE 242	Digital Electronics and Microprocessor	3-1-0	4
EE 243	Analog Electronics	3-1-0	4
EE 244	Signals & Systems	3-1-0	4
EE 336	Advanced Instrumentation	3-0-0	3
EE 341	Embedded Systems	3-0-0	3
EE 345	Communication Systems Principles	3-0-0	3
EE 355	Computer Organization & Operating Systems	3-0-0	3
EE 356	Digital Signal Processing	3-0-0	3
EE 445	Data Communication & Networks	3-1-0	4
EE 454	Digital Communication	3-0-0	3
EE 455	Digital Signal Processing	3-1-0	4
EE 456	Robotics & Computer Vision	3-0-0	3
EE 641	Digital Communication	3-1-0	4
EE 642	Wireless Communication	3-1-0	4
EE 643	Microwave & Antenna Systems	3-1-0	4

EE 645	Adaptive Signal Processing	3-1-0	4
EE 647	Wireless Networks & Protocols	3-1-0	4
EE 649	Wireless Sensor Networks	3-1-0	4
EE 651	Digital Speech Processing	3-1-0	4
EE 652	Ad-Hoc Networks	3-1-0	4
EE 653	Digital Image Processing	3-1-0	4
EE 654	Satellite Communication	3-1-0	4
EE 655	VLSI Signal Processing	3-1-0	4
EE 657	Optical communication	3-1-0	4
EE 659	Digital VLSI Design	3-1-0	4
EE 661	Advanced Signal Processing	3-1-0	4
EE 663	Microprocessor and Microcontroller Systems	3-1-0	4
EE 664	Embedded Computing Systems	3-1-0	4
EE 667	Microelectronic Devices and Circuits	3-1-0	4
EE 668	Instrumentation and Sensors	3-1-0	4

Sub Discipline:	**Control and Automation**		
EE 322	Control System – I	3-1-0	4
EE 425	Control System – II	3-1-0	4
EE 426	Fuzzy Modeling & Control	3-0-0	3
EE 427	Soft Computing	3-1-0	4
EE 429	Advanced Control Theory	3-1-0	4
EE 436	Adaptive Control and System Identification	3-0-0	3
EE438	**Industrial Automation & Control**	3-0-0	3

Sub Discipline:	**Laboratory Courses**		
EE 270	Basic Electrical Engineering Laboratory	0-0-3	2
EE 271	Network Laboratory	0-0-3	2
EE 272	Measurement Laboratory	0-0-3	2
EE 274	Electronics Laboratory	0-0-3	2
EE 277	Electrical Machines Laboratory-I	0-0-3	2
EE 370	Power Electronics Laboratory	0-0-3	2
EE 371	Communication System Laboratory	0-0-3	2
EE 372	Control System Laboratory	0-0-3	2
EE 373	Electrical Machines Laboratory – II	0-0-3	2
EE 374	Electrical System Simulation Laboratory	0-0-3	2
EE 375	Embedded Systems Laboratory	0-0-3	2
EE 376	Power System Laboratory	0-0-3	2
EE 377	Electrical Machine Design	0-0-3	2
EE 471	Electrical Drives Laboratory	0-0-3	2
EE 472	Control & Electrical System Design	0-0-3	2
EE 671	Microwave & Antenna Laboratory	0-0-3	2

EE 672	Advanced Communication Laboratory	0-0-3	2
EE 673	Modeling & Simulation Laboratory	0-0-3	2
EE 674	Embedded Systems Laboratory	0-0-3	2
EE 675	Power Electronics and Drives Laboratory – I	0-0-3	2
EE 676	Power Electronics and Drives Lab – II	0-0-3	2
EE 677	Machines and Control Laboratory	0-0-3	2
EE 678	Power Electronics and Drives Simulation Lab	0-0-3	2
EE 679	Control Systems Laboratory	0-0-3	2

Sub Discipline:	Project, Seminar and Special Courses		
EE 391	Special Topic in Electrical Engineering – I		¾
EE 392	Special Topic in Electrical Engineering – II		¾
EE 393	Special Laboratory in Electrical Engineering – I	0-0-3	2
EE 394	Special Laboratory in Electrical Engineering – II	0-0-3	2
EE 395	Engineering Product Development Project – I	0-0-6	4
EE 396	Engineering Product Development Project – II	0-0-6	4
EE 491	Research Project – I	0-0-3	2
EE 492	Research Project – II	0-0-3	2
EE 493	Seminar and Technical Writing – I	0-0-3	2
EE 494	Seminar and Technical Writing – II	0-0-3	2
EE 495	Short Term Industrial/ Research Experience	0-0-3	2
EE 681	Special Topics in Electrical Engineering – I		3/4
EE 682	Special Topics in Electrical Engineering – II		3/4
EE 683	Special Laboratory in Electrical Engineering – I	0-0-3	2
EE 684	Special Laboratory in Electrical Engineering –II	0-0-3	2
EE 687	Seminar & Technical Writing – III	0-0-3	2
EE 688	Seminar & Technical Writing – IV	0-0-3	2
EE 691	Short Term Industrial/ Research Project	0-0-0	4
EE 692	Comprehensive Viva –Voce	0-0-0	4
EE 693	Research Project – III	0-0-0	10
EE 694	Research Project – IV	0-0-0	10
EE 695	Research Project – V	0-0-30	20

DEPARTMENT OF INDUSTRIAL DESIGN

Curriculum of B.Tech (Industrial Design)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub.Code	Subjects		L-T-P	Credits
1	MA 101	Mathematics-I		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		**15-5-15**	**30**

SECOND SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub.Code	Subjects		L-T-P	Credits
1	MA 102	Mathematics-II		3-1-0	4
2	PH 102	Physics-II		3-1-0	4
3	CS 102	Data Structures and Algorithm		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 - II		0-0-3	2
		TOTAL		**15-5-15**	**30**

THIRD SEMESTER

Sl. No	Sub.Code	Subjects		L-T-P	Credits
1	MA 201	Mathematics–III		3-1-0	4
2	ME 213	Mechanics of Solids		3-1-0	4
3	ME 250	Thermal Engineering		3-0-0	4
4	ID 221	Mechanisms and Mechines		3-1-0	4
5		HS & Open Elective-I		3-0-0	3
6	EE 270	Basic Electrical Engineering Laboratory	OR	0-0-3	2
	EC 270	Basic Electronics Laboratory			

7	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
8	CE 271	Mechanics of Solids Laboratory		0-0-3	2
TOTAL					**25**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects		L-T-P	Credits
1	MA 202	Mathematics – IV		3-1-0	4
2	ME 210	Design of Machine Elements		3-1-0	4
3	ID 222	Geometric and Solid Modeling		3-1-0	4
4	ID 232	Art and Aesthetic Design		3-1-0	4
		HS & Open Elective – II		3-0-0	3
5	EE 270	Electrical Engineering Laboratory – I	OR	0-0-3	2
	EC 270	Basic Electronics Laboratory			
6	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
7	ME 280	Machine Element Design Practice -I		0-0-3	2
8	ID 272	Design workshop – I		0-0-3	2
TOTAL					**27**

FIFTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	ID 311	Product Design - I	3-1-0	4
2	ID 341	Manufacturing Processes	3-1-0	4
3	ID 351	Industrial Mechatronics	3-1-0	4
4		Professional Elective – I	3-0-0	3
5		HS & Open Elective – III	3-0-0	3
6	WS 371	Advanced Machining Practice	0-0-3	2
7	ID 371	Art,Design & Aesthetic Laboratory	0-0-3	2
8	ID 373	Product Design Laboratory -I	0-0-3	2
9	ID 381	Industrial Design Project –I	0-0-3	2
TOTAL				**26**

SIXTH SEMESTER

Sl. No	Sub.Code	Subjects	L-T-P	Credits
1	ID 312	Product Design - II	3-1-0	4
2	MM 314	Heat Treatment of Metallic Materials	3-1-0	4
3		Professional Elective – II	3-0-0	3
4		Professional Elective – III	3-0-0	3
5		HS & Open Elective – IV	3-0-0	3
6	ID 372	Design workshop - II	0-0-3	2
7	ID 374	Product Design Laboratory -II	0-0-3	2
8	ID 376	Creative Automation Laboratory	0-0-3	2
9	ID 382	Industrial Design Project –II	0-0-3	2

TOTAL	25

SEVENTH SEMESTER

Sl. No	Sub.Code	Subjects	L-T-P	Credits
1	ID 431	Ergonomics in Design	3-1-0	4
2	ID 441	Computer -Aided Manufacturing	3-1-0	4
3		Professional Elective –IV	3-0-0	3
4		HS & Open Elective – V	3-0-0	3
5	ID 471	Ergonomics Simulation Laboratory	0-0-3	2
6	ID 491	Research Project – I	0-0-6	4
7	ID 493	Seminar & Technical Writing – I	0-0-3	2
8	ID 495	Short term Industrial / Research Experience	0-0-3	2
TOTAL				24

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Elective – V	3-1-0	4
2		Professional Elective – VI	3-1-0	4
3		Professional Elective – VII	3-0-0	3
4		HS & Open Elective – VI	3-0-0	3
5	ID 492	Research Project – II	0-0-9	6
6	ID 494	Seminar & Technical Writing – II	0-0-3	2
7	ID 496	Comprehensive Viva Voce	0-0-3	2
TOTAL				24

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub.Code	Subjects	L-T-P	Credits
1	ID 321	Thermal Considerations in Design	3-0-0	3
2	ID 333	Interaction Design snd Usability Engineering	3-0-0	3
3	ID 344	Design of Production Tooling	3-0-0	3
4	ID 352	Industrial Robotics	3-0-0	3
5	ID 354	Instrumentation and Control	3-0-0	3
6	ID 391	Special Topics in Industrial Design -- I		3/4
7	ID 392	Special Topics in Industrial Design -- II		3/4
8	ID 393	Special Laboratory in Industrial Design -- I	0-0-6	4
9	ID 394	Special Laboratory in Industrial Design – II	0-0-6	4
10	ID 432	System Design for Sustainability	3-1-0	4
11	ID 433	Visual Design	3-0-0	3
12	ID 434	Photo Communication	3-0-0	3
13	ID 442	Rapid Product Development Technologies	3-1-0	4
14	ID 444	Design for Manufacture and Assembly	3-1-0	4
15	ID 451	Industrial Automation	3-0-0	3

PROFESSIONAL ELECTIVES FROM OTHER DEPARTMENTS

Sl. No	Sub. Code	Subject	L-T- P	Credits
1	BM 320	Bio-Ceramic	3-0-0	3
2	BM 321	Bio-Materials	3-0-0	3
3	BM 322	Bio-Mechanics	3-0-0	3
4	BM 421	Bio-Composites	3-0-0	3
5	BM 423	Tissue Engineering	3-0-0	3
6	ME 333	Process Control and Assurance Science	3-0-0	3
7	ME 435	Concurrent Engineering	3-0-0	3

LIST OF OPEN ELECTIVES

Sl. No	Sub. Code	Subjects	L-T- P	Credits	Non Eligible Branches
1	ID 200	Design and Society	3-0-0	3	-
2	ID 220	Fundamentals of Computer Graphics and Solid Modeling	3-0-0	3	-
3	ID 230	Environmental and Experimental Design	3-0-0	3	-
4	ID 310	Value Engineering	3-0-0	3	-
5	ID 350	Robotics and Automation	3-0-0	3	-
6	ID 410	Project Management	3-0-0	3	-
7	ID 440	Rapid Prototyping	3-0-0	3	-

SUMMARY OF COURSES

Sub Discipline: Product Design

ID 310	Value Engineering	3-0-0	3
ID 311	Product Design - I	3-1-0	4
ID 312	Product Design - II	3-1-0	4
ID 410	Project Management	3-0-0	3

Sub Discipline: Design and Analysis

ID220	Fundamentals of Computer Graphics and Solid Modeling	3-0-0	3
ID 221	Mechanism of Machines	3-1-0	4
ID 222	Geometric and Solid Modeling	3-1-0	4
ID 321	Thermal Considerations in Design	3-0-0	3

Sub Discipline: Ergonomics and Aesthetic Design

ID 200	Design and Society	3-0-0	3
ID 230	Environmental and Experimental Design	3-0-0	3
ID 232	Art and Aesthetic Design	3-1-0	4
ID 333	Interaction Design and Usability Engineering	3-0-0	3
ID 431	Ergonomics in Design	3-1-0	4
ID 432	System Design for Sustainability	3-0-0	3

ID 433	Visual Design	3-0-0	3
ID 434	Photo Communication	3-0-0	3
Sub Discipline:	**Manufacturing**		
ID 341	Manufacturing Process	3-1-0	4
ID 344	Design of Production Tooling	3-0-0	3
ID 440	Rapid Prototyping	3-1-0	4
ID 441	Computer Aided Manufacturing	3-1-0	4
ID 442	Rapid Product Development Technologies	3-1-0	4
ID 444	Design for Manufacture and Assembly	3-1-0	4
Sub Discipline:	**Automation & Control**		
ID 350	Robotics and Automation	3-0-0	3
ID 351	Industrial Mechatronics	3-1-0	4
ID 352	Industrial Robotics	3-0-0	3
ID 354	Insrumentation and Control	3-0-0	3
ID 451	Industrial Automation	3-0-0	3
Sub Discipline:	**LaboratoryCourses**		
ID 272	Design Workshop-I	0-0-3	2
ID 371	Art, Design & Aesthetic Laboratory	0-0-3	2
ID 372	Design workshop - II	0-0-3	2
ID 373	Product Design Laboratory - I	0-0-3	2
ID 374	Product Design Laboratory – II	0-0-3	2
ID 376	Creative Automation Laboratory	0-0-3	2
ID 471	Ergonomics Simulation Laboratory	0-0-3	2
Sub Discipline:	**Project, Seminar & Special Courses**		
ID 381	Industrial Design Project - I	0-0-3	2
ID 382	Industrial Design Project - II	0-0-3	2
ID 391	Special Topic in IndustrialDesign–I		3/4
ID 392	Special Topic in Industrial Design-II		3/4
ID 393	Special Laboratory in Industrial Design- I	0-0-6	4
ID 394	Special Laboratory in Industrial Design - II	0-0-6	4
ID 491	Research Project – I	0-0-6	4
ID 492	Research Project – II	0-0-9	6
ID 493	Seminar & Technical Writing – I	0-0-3	2
ID 494	Seminar & Technical Writing – II	0-0-3	2
ID 495	Short Term Industrial/Research Experience	0-0-0	2
ID 496	Comprehensive Viva Voce	0-0-0	2

DEPARTMENT OF FOOD PROCESS ENGINEERING

Vision

To addresses the modern issues related to food processing and implement changes that incorporate cutting-edge research and technology to meet the challenges of today and the future food industry as well as to invigorate the program, and the profession at large, by redefining the practice of food process engineering for modern society.

Mission

I. To execute basic and applied research that advances the state of the profession.
II. To educate the next generation of academic and industry leaders, and preparation of students for successful careers in professional practice.
III. To contribute in selected services to institutions and government for assessing the technical resources and promoting solutions to meet significant societal problems related to food security, safety and processing.

B. Tech (Food Process Engineering)

Program Educational Objectives (PEOs)

1. To develop knowledge and understanding about systems in the production, processing and consumption of food and an appreciation of their impact on society.
2. To impart knowledge about the nature of food and human nutrition and an appreciation of the importance of food to health.
3. To build up skills in researching, analyzing and communicating issues related to food preservation, processing, storage and packaging.
4. To enhance skills in experimenting with and development of food products and equipment by applying theoretical concepts.
5. To develop skills in designing, implementing and evaluating solutions to food industry situations.

Program Outcomes (POs)

1. Students will develop ability to identify and discuss a range of historical and contemporary factors which influence the consumption of particular food product as well as accounts for individual and group food selection patterns in terms of physiological, psychological, social and economic factors.
2. Students will develop ability to explain and understand manufacturing processes and technologies used in the production of food products, examine the nature and extent of the food industry, justi-

fy processes of food product manufacturing and equipment design in terms of market, technological and environmental considerations.

3. Students will develop ability to evaluate the impact of the good manufacturing practices within the Indian food industry on the individual, society and environment.
4. Students will develop ability to explain the role of nutrients in human health and develop, prepare and present food products using modern processing, preservation and packaging techniques.
5. Students will develop ability to evaluate the relationship between food production, consumption, promotion and health.
6. Students will develop skills in regulating food product manufacturing process, storage, distribution, sale and import to ensure availability of safe and wholesome food for human consumption.
7. Students will be able to provide scientific advice and technical support to food industry covered under Food Safety and Standards Authority of India, US FDA regulations and other related food standards.

Course Outcomes (COs):

a) An ability to apply knowledge of mathematics, science and engineering in food processing.

b) An ability to design and conduct experiments, analyze and interpret data as well as prediction of data using mathematical modelling

c) An ability to design a food product, system, component, or process to meet desired needs of food industry

d) An ability to function on multi-disciplinary teams.

e) An ability to identify, formulate and solve food engineering and food safety problems.

f) An understanding of professional and ethical responsibilities.

g) An ability to communicate effectively when practicing food engineering profession.

h) Understanding the impact of engineering solutions in a global/societal context.

i) Recognition of the need for and an ability to engage in life-long learning.

j) Knowledge of contemporary issues of food processing and food safety.

k) An ability to use the techniques, skills, and modern engineering tools necessary for food engineering practice.

l) Ability to provide service to food industry for developing/ operating their manufacturing system in compliance with national and international food standards and regulations.

DEPARTMENT OF FOOD PROCESS ENGINEERING

Curriculum of B.Tech. (Food Process Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T-P	Credits
1	MA 101	Mathematics – I		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	Mathematics – II		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		3-1-0	
5	CE 130	Environmental and Safety Engineering	OR	3-1-0	4
	CE 100	Engineering Mechanics		3-1-0	
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 – II		0-0-3	2
Total					**30**

THIRD SEMESTER

Sl. No	Sub. Code	Subjects		L-T-P	Credits
1	MA 201	Mathematics – III		3-1-0	4
2	FP 201	Food Microbiology		3-1-0	4
3	CH 213	Chemical Engineering Thermodynamics		3-1-0	4
4	CH 215	Fluid Dynamics		3-1-0	4
5		HS & Open Elective – I		3-0-0	3
6	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
7	EE 270	Electrical Engineering Laboratory - I	OR	0-0-3	2
	EC 270	Basic Electronics Laboratory			
8	FP 271	Engineering Properties of Biological Materials Laboratory		1-0-2	2
9	FP 273	Food Microbiology Laboratory		0-0-3	2
Total					**27**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects		L-T-P	Credits
1	MA 202	Mathematics – IV		3-1-0	4
2	FP 210	Food Chemistry		3-1-0	4
3	FP 212	Processing of Grains and Horticultural Products		3-1-0	4
4	FP 224	Unit Operations in Food Processing		3-1-0	4
5		HS & Open Elective – II		3-0-0	3
6	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
7	EE 270	Electrical Engineering Laboratory- I	OR	0-0-3	2
	EC 270	Basic Electronics Laboratory			
8	FP 272	Food Chemistry Laboratory		0-0-3	2
9	FP 274	Food Grains Processing Laboratory		0-0-3	2
		Total			**27**

FIFTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	FP 331	Heat and Mass Transfer	3-1-0	4
2	FP 333	Dairy Process Engineering	3-1-0	4
3	FP 335	Refrigeration and Air Conditioning Engineering	3-1-0	4
4	FP 337	Food Packaging and Storage Engineering	3-1-0	4
5		HS & Open Elective – III	3-0-0	3
6	FP 371	Heat and Mass Transfer Laboratory	0-0-3	2
7	FP 373	Unit Operations in Food Processing Laboratory	0-0-3	2
8	FP 375	Horticultural Processing Laboratory	0-0-3	2
9	FP 377	Dairy Process Engineering Laboratory	0-0-3	2
		Total		**27**

SIXTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Elective – I	3-0-0	3
2		Professional Elective –II	3-0-0	3
3		Professional Elective –III	3-0-0	3
4		Professional Elective – IV	3-0-0	3
5		HS & Open Elective – IV	3-0-0	3
6	FP 372	Food Process Equipment and Plant Design Laboratory	0-0-3	2
7	FP374	Refrigeration and Air Conditioning Engineering Laboratory	0-0-3	2
8	FP 376	Food Packaging and Storage Design Laboratory	0-0-3	2
9	FP 378	Food Analysis and Quality Control Laboratory	0-0-3	2
10	FP 390	Research Practice	0-0-0	2
11	CH272	Fluid Dynamics Fundamentals Laboratory	0-0-3	2
		Total		**27**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Elective – V	3-0-0	3
2		Professional Elective – VI	3-0-0	3
3		Professional Elective – VII	3-0-0	3
4		HS & Open Elective – V	3-0-0	3
5	FP 471	Livestock, Fish and Marine Products Processing Laboratory	1-0-2	2
6	FP 473	Food Process Modeling and Simulation Laboratory	1-0-2	2

7	FP 490	Short term Industrial / Research Experience	0-0-3	2
8	FP 493	Research Project – I	0-0-6	4
9	FP 495	Seminar and Technical Writing – I	0-0-3	2
		Total		**24**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Elective – VIII	3-0-0	3
2		Professional Elective – IX	3-0-0	3
3		Professional Elective – X	3-0-0	3
4		HS & Open Elective – VI	3-0-0	3
5	FP 472	Experimental Design and Statistical Methods Laboratory	1-0-2	2
6	FP 494	Seminar and Technical Writing – II	0-0-3	2
7	FP 496	Research Project – II	0-0-9	6
8	FP 498	Comprehensive Viva Voce	0-0-0	2
		Total		**24**

LIST OF PROFESSIONAL ELECTIVES

Sr. No.	Sub. Code	Subject	L-T-P	Credits
1.	FP 312	Processing of Spices, Condiments and Plantation crops	3-0-0	3
2.	FP 332	Food Process Equipment and Plant Design	3-0-0	3
3.	FP 334	Biochemistry and Human Nutrition	3-0-0	3
4.	FP 352	Emerging Technologies in Food Processing	3-0-0	3
5.	FP 336	Functional Foods and Nutraceuticals	3-0-0	3
6.	FP 338	Processing of Livestock, Fish and Marine Products	3-0-0	3
7.	FP 323	Beverage Technology	3-0-0	3
8.	FP 325	Food Analysis and Quality Control	3-0-0	3
9.	FP 326	Food Product Development	3-0-0	3
10.	FP 328	Food Industry by-product and Waste Management	3-0-0	3
11.	FP 412	Food Laws, Regulations & Certifications	3-0-0	3
12.	FP 414	Food Ingredients and Additives	3-0-0	3
13.	FP 421	Bakery and Confectionary Technology	3-0-0	3
14.	FP 424	IT Applications in Food Industry	3-0-0	3
15.	FP 427	Food Business Management & Entrepreneurship Development	3-0-0	3
16.	FP 430	Separation Techniques in Food Engineering	3-0-0	3
17.	FP 433	Process Control and Instrumentation in Food Industry	3-0-0	3
18.	FP 434	Food Process Modeling and Simulation	3-0-0	3

19.	FP 491	Special Topic in Food Engineering – I	3-0-0	3
20.	FP 492	Special Topic in Food Engineering – II	3-0-0	3

PROFESSIONAL ELECTIVES FROM OTHER DEPARTMENTS

Sl. No.	Sub. Code	Subject	L-T-P	Credits
1	CH 321	Fundamentals of Biochemical Engineering	3-0-0	3
2	CH 323	Energy Conservation and Renewable sources of Energy	3-0-0	3
3	PH 351	Science of Nano-materials	3-0-0	3
4	CY 431	Chemistry of Nanomaterials	3-0-0	3
5	CY 432	Introduction to Nanobiotechnology	3-0-0	3
6	BM 452	Fermentation Technology	3-0-0	3
7	MM 449	Nanostructured Materials	3-0-0	3
8	SM 504	Production and Operations Management	3-0-0	3
9	LS 542	Basic Biotechnology	3-0-0	3
10	SM 616	Retail Management	3-0-0	3
11	CH 625	Bioprocess Engineering	3-0-0	3
12	BM 653	Bioprocess and Plant Design	3-0-0	3

DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum of B. Tech (Mechanical Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Mathematics – I		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				**15-5-15**	**30**

SECOND SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Mathematics – II		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithm		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 – II		0-0-3	2
TOTAL				**15-5-15**	**30**

THIRD SEMESTER

Sl. No	Sub.Code	Subjects	L-T- P	Credits
1	MA 201	Mathematics – III	3-1-0	4
2	ME 211	Kinematics and Dynamics of Machinery	3-1-0	4
3	ME 213	Mechanics of Solids	3-1-0	4
4	ME 251	Engineering Thermodynamics	3-1-0	4

5		HS & Open Elective – I		3-0-0	3
6	EE 270 EC 270	Electrical Engineering Laboratory - I Basic Electronics Laboratory	OR	0-0-3	2
7	MA 270 HS 270	Numerical Methods Laboratory Language Laboratory	OR	0-0-3	2
8	CE 271	Mechanics of Solids Laboratory		0-0-3	2
		TOTAL			**25**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 202	Mathematics – IV		3-1-0	4
2	EE 202	Electrical Engineering		3-1-0	4
3	ME 210	Design of Machine Elements		3-1-0	4
4	ME 230	Primary Production Processes		3-1-0	4
5		HS &Open Elective – II		3-0-0	3
6	EC 270 EE 270	Basic Electronics Laboratory Electrical Engineering Laboratory – I	OR	0-0-3	2
7	MA 270 HS 270	Numerical Methods Laboratory Language Laboratory	OR	0-0-3	2
8	WS 270	Advanced Manufacturing Practice – I		0-0-3	2
9	ME 280	Machine Element Design Practice – I		0-0-3	2
		TOTAL			**25**

FIFTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	ME 331	Metal Machining and Automation	3-1-0	4
2	ME 351	Fluid Mechanics	3-1-0	4
3		Professional Elective – I	3-0-0	3
4		Professional Elective – II	3-0-0	3
5		HS &Open Elective – III	3-0-0	3
6	WS 371	Advanced Manufacturing Practice – II	0-0-3	2
7	ME 373	Production Engineering Laboratory	0-0-3	2
8	ME 375	Internal Combustion Engines and Automobile Engineering Laboratory	0-0-3	2
9	ME 381	Machine Element Design Practice – II	0-0-3	2
		TOTAL		**25**

SIXTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	ME 330	Metal Cutting and Tool Design	3-1-0	4
2	ME 350	Heat Transfer	3-1-0	4
3		Professional Elective – III	3-0-0	3
4		Professional Elective – IV	3-0-0	3
5		HS &Open Elective – IV	3-0-0	3

6	ME 370	Heat Transfer and Refrigeration Lab.	0-0-3	2
7	ME 372	Fluid Mechanics & Fluid Machines Lab.	0-0-3	2
8	ME 374	Computational Fluid Dynamics Lab.	0-0-3	2
9	ME 380	Production Engineering Project	0-0-3	2
TOTAL				**25**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Elective – V	3-0-0	3
2		Professional Elective – VI	3-0-0	3
3		Professional Elective – VII	3-0-0	3
4		HS &Open Elective – V	3-0-0	3
5	ME 481	Mechanical System Design Project	0-0-3	2
6	ME 483	Industrial Engineering Project	0-0-3	2
7	ME 491	Research Project – I	0-0-6	4
8	ME 493	Seminar and Technical Writing – I	0-0-3	2
9	ME 495	Short term Industrial/Research Experience	0-0-3	2
TOTAL				**24**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Elective – VIII	3-0-0	3
2		Professional Elective – IX	3-0-0	3
3		Professional Elective – X	3-0-0	3
4		HS &Open Elective – VI	3-0-0	3
5	ME 470	Design Engineering Lab.	0-0-3	2
6	ME 480	Thermal Engineering Design Project	0-0-3	2
7	ME 492	Research Project – II	0-0-9	6
8	ME 494	Seminar and Technical Writing – II	0-0-3	2
9	ME 496	Comprehensive Viva – Voce	0-0-0	2
TOTAL				**26**

Curriculum of M. Tech Dual Degree (Specialization: Mechatronics & Automation)

[1st Semester to 6th Semester is common to B.Tech. Mechanical Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	ME 600	Applied Finite Element Analysis	3-1-0	4
2	ME 610	Analysis and Synthesis of Mechanism	3-1-0	4
3		Professional Elective – V (B.Tech.)	3-1-0	4
4		Professional Elective – VI (B.Tech.)	3-1-0	4
5		Professional Elective – VII (B.Tech.)	3-1-0	4
6		Elective Laboratory – I	0-0-3	2

7		Elective Laboratory – II	0-0-3	2
8	ME 491	Research Project – I	0-0-3	2
9	ME 493	Seminar and Technical Writing – I	0-0-3	2
10	ME 691	Short Term Industrial/Research Experience	0-0-0	2
		TOTAL	**15-2-12**	**30**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	ME 601	Optimization Methods in Engg. Design	3-1-0	4
2	ME 604	Advanced Mechatronics	3-1-0	4
3		Professional Elective – VIII (B.Tech.)	3-0-0	3
4		Professional Elective – IX (B.Tech.)	3-0-0	3
5		Professional Elective – X (B.Tech.)	3-0-0	3
6		Elective Laboratory – III	0-0-3	2
7		Elective Laboratory – IV	0-0-3	2
8	ME 494	Seminar and Technical Writing – II	0-0-3	2
9	ME 492	Research Project – II	0-0-3	2
		TOTAL	**15-2-12**	**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Elective – I (M. Tech.)		3/4
2		Professional Elective – II (M. Tech.)		3/4
3		Professional Elective – III (M. Tech.)		3/4
4	ME 687	Seminar and Technical Writing – III	0-0-3	2
5	ME 693	Research Project – III(Summer)	0-0-0	10
6	Me 694	Research Project – IV	0-0-0	10
		TOTAL	**9-3-3**	**31/34**

TENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	ME 688	Seminar and Technical Writing – IV	0-0-3	2
2	ME 692	Comprehensive Viva Voce	0-0-0	4
3	ME 695	Research Project – V	0-0-30	20
		TOTAL	**0-0-33**	**26**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subject	L-T- P	Credits	Offered to
1	ME 313	Fundamentals of Ergonomics	3-0-0	3	@
2	ME 332	Advanced Manufacturing Process	3-0-0	3	#
3	ME 333	Process Control and Assurance Science	3-0-0	3	#
4	ME 334	Surface Engineering	3-0-0	3	@
5	ME 335	Metrology and Computer Aided Inspection	3-0-0	3	#

6	ME 336	Plastic Part Manufacturing and Tool Design	3-0-0	3	@
7	ME 352	Fluid Dynamics and Hydraulic Machines	3-0-0	3	@
8	ME 353	Internal Combustion Engines	3-0-0	3	@
9	ME 354	Refrigeration and Air-Conditioning	3-0-0	3	@
10	ME 355	Aircraft and Rocket Propulsion	3-0-0	3	@
11	ME 356	Turbo-machinery	3-0-0	3	@
12	ME 357	Gas Dynamics	3-0-0	3	@
13	ME 391	Special Topic in Mechanical Engineering – I		3/4	@
14	ME 392	Special Topic in Mechanical Engineering – II		3/4	@
15	ME 393	Special Laboratory in Mechanical Engg – I	0-0-3	2	@
16	ME 394	Special Laboratory in Mechanical Engg – II	0-0-3	2	@
17	ME 395	Engineering Product Development Project – I	0-0-6	4	@
18	ME 396	Engineering Product Development Project – II	0-0-6	4	@
19	ME 410	Advanced Mechanics of Solids	3-0-0	3	#
20	ME 411	Vibration and Noise Engineering	3-0-0	3	#
21	ME 412	Advanced Machine Dynamics	3-0-0	3	#
22	ME 413	Experimental Stress Analysis	3-0-0	3	#
23	ME 414	Mechatronics	3-0-0	3	#
24	ME 415	Fundamentals of Tribology	3-0-0	3	@
25	ME 416	Robotics	3-0-0	3	#
26	ME 418	Material Handling	3-0-0	3	#
27	ME 431	Decision Modeling	3-0-0	3	#
28	ME 432	Non-Conventional Machining Processes	3-0-0	3	#
29	ME 433	Advanced Manufacturing Systems	3-0-0	3	#
30	ME 434	Computer Graphics for CAD/CAM	3-0-0	3	#
31	ME 435	Concurrent Engineering	3-0-0	3	#
32	ME 437	Welding Technology	3-0-0	3	@
33	ME 440	Industrial Management	3-0-0	3	@
34	ME 451	Power Plant Engineering	3-0-0	3	@
35	ME 453	Energy Conservation & Waste Heat Recovery	3-0-0	3	@
36	ME 455	Nuclear Power Generation and Safety	3-0-0	3	@
37	ME 602	Robotics	3-1-0	4	$
38	ME 605	Advanced Decision Modeling Technique	3-1-0	4	$
39	ME 606	Neural Network & Artificial Intelligence	3-1-0	4	$
40	ME 607	Concurrent Engineering	3-1-0	4	$
41	ME 608	Control system Engineering	3-1-0	4	$
42	ME 611	Vibration Analysis & Diagnostics	3-1-0	4	$
43	ME 612	Non-Traditional Parameter in Design	3-1-0	4	$
44	ME 613	Design of Material Handling Equipment	3-1-0	4	$
45	ME 615	Computer Aided Design of Machines	3-1-0	4	$
46	ME 617	Intelligent System Control	3-1-0	4	$

47	ME 625	Intelligent Industrial Automation and its Application	3-1-0	4	$
48	ME 631	Production Technology	3-1-0	4	$
49	ME 635	Product Design for Manufacturing	3-1-0	4	$
50	ME 637	Production System & Computer Integrated Manufacturing	3-1-0	4	$
51	ME 641	Knowledge Based Systems in Manufacturing	3-1-0	4	$
52	ME 642	CNC Machine Tools and Automated Manufacturing	3-1-0	4	$
53	ME 645	Soft Computing for Intelligent Manufacturing	3-1-0	4	$
54	ME 681	Special Topics in Mechanical Engineering – I	3-1-0	4	$
55	ME 682	Special Topics in Mechanical Engineering – II	3-1-0	4	$

Notes: *# (B.Tech. and all dual degree courses), $(only for dual degree courses), @ (only for B.Tech courses)*

PROFESSIONAL ELECTIVES OFFERED BY OTHER DEPARTMENTS

Sl. No	Sub.Code	Subject	L-T-P	Credits	Offered to
1	BM 388	Biosensors and Diagnostics	3-0-0	3	$
2	CE 316	Advanced Mechanics of Solids	3-1-0	4	#
3	CE 318	Finite Element Method	3-1-0	4	$
4	CE 352	Advanced Fluid Mechanics	3-1-0	4	@
5	CH 226	Fuels and Combustion	3-0-0	4	@
6	CH 415	Fluidization Engineering	3-1-0	4	@
7	CH 419	Computational Fluid Dynamics	3-1-0	4	@
8	CH 432	Optimization Techniques in Process Design	3-0-0	3	@
9	CR 433	Sensor Technology	3-0-0	3	$
10	CS 315	Optimization Techniques	3-1-0	4	$
11	CS 335	Computer Graphics & Multimedia	3-1-0	4	$
12	CS 435	Artificial Intelligence	3-0-0	3	#
13	CS 437	Soft Computing	3-0-0	3	#
14	CS 439	Computer Vision	3-0-0	3	$
15	CS 637	Digital Signal Processing	3-1-0	4	$
16	EC 433	Process Control Instrumentation	3-0-0	3	$
17	EC 443	Digital Image Processing	3-0-0	3	$
18	EC 444	Soft Computing	3-1-0	4	$
19	EC 448	Evolutionary Computing Techniques	3-1-0	4	$
20	EE 426	Fuzzy Modeling and Control	3-0-0	3	$
21	EE 427	Artificial Neural Network	3-0-0	3	$
22	EE 445	Digital Communication	3-0-0	3	$
23	EE 454	Data Communication & Networks	3-0-0	3	$
24	EE 456	Robotics and Computer Vision	3-0-0	3	$
25	EE 634	Robotics & Automation	3-1-0	4	$

26	EE 636	Intelligent Control	3-1-0	4	$
27	EE 637	Soft Computing Techniques	3-1-0	4	$
28	EE 668	Instrumentation and Sensors	3-1-0	4	$
29	MA 512	Fourier Analysis	3-1-0	4	#
30	MA 530	Computational Methods in Boundary Value Problems	3-1-0	4	@
31	MA 531	Boundary Layer Theory	3-1-0	4	@
32	MA 532	Numerical Solution of Partial Differential Equations	3-1-0	4	@
33	MM 336	Mechanical Working of Metallic Materials	3-1-0	4	@
34	MM 435	Fracture Mechanics and Failure Analysis	3-1-0	4	@
35	MM 449	Nanostructured Materials	3-0-0	3	@

***Notes:** *# (B.Tech. and all dual degree courses), $(only for dual degree courses), @ (only for B.Tech courses)*

COURSES OFFERED AS OPEN ELECTIVES

(Normally not offered to students of Mechanical Engineering)

Sl. No	Sub. Code	Subject	L-T- P	Credits
1	ME 231	Total Quality Management	3-0-0	3
2	ME 253	Heat Transfer Problems in Electronics and Instrumentation	3-0-0	3
3	ME 254	Renewable Energy Systems	3-0-0	3
4	ME 256	The Quest for Absolute Zero	3-0-0	3
5	ME 300	Finite Element Analysis	3-0-0	3
6	ME 311	Composite Material	3-0-0	3
7	ME 417	Control System Engineering	3-0-0	3
8	ME 430	Industrial Management	3-0-0	3
9	ME 436	Entrepreneurship	3-0-0	3
10	ME 450	Computational Fluid Dynamics & Heat Transfer	3-0-0	3
11	ME 457	Cryogenic Engineering	3-0-0	3

SUMMARY OF COURSES

Sub discipline:	Design Engineering Group		
ME 210	Design of Machine Elements	3-1-0	4
ME 211	Kinematics and Dynamics of Machinery	3-1-0	4
ME 213	Mechanics of Solids	3-1-0	4
ME 313	Fundamentals of Ergonomics	3-0-0	3
ME 410	Advanced Mechanics of Solids	3-0-0	3
ME 411	Vibration and Noise Engineering	3-0-0	3
ME 412	Advanced Machine Dynamics	3-0-0	3
ME 413	Experimental Stress Analysis	3-0-0	3
ME 414	Mechatronics	3-0-0	3
ME 415	Fundamentals of Tribology	3-0-0	3
ME 416	Robotics	3-0-0	3

ME 418	Material Handling	3-0-0	3
ME 600	Applied Finite Element Analysis	3-1-0	4
ME 601	Optimization Methods in Engg. Design	3-1-0	4
ME 602	Robotics	3-1-0	4
ME 604	Advanced Mechatronics	3-1-0	4
ME 605	Advanced Decision Modeling Technique	3-1-0	4
ME 606	Neural Network & Artificial Intelligence	3-1-0	4
ME 607	Concurrent Engineering	3-1-0	4
ME 608	Control system Engineering	3-1-0	4
ME 610	Analysis and Synthesis of Mechanism	3-1-0	4
ME 611	Vibration Analysis & Diagnostics	3-1-0	4
ME 612	Non-Traditional Parameter in Design	3-1-0	4
ME 613	Design of Material Handling Equipment	3-1-0	4
ME 615	Computer Aided Design of Machines	3-1-0	4
ME 617	Intelligent System Control	3-1-0	4
ME 625	Intelligent Industrial Automation and its Application	3-1-0	4

Sub discipline:	Production Engineering Group		
ME 230	Primary Production Processes	3-1-0	4
ME 231	Total Quality Management	3-0-0	3
ME 330	Metal Cutting and Tool Design	3-1-0	4
ME 331	Metal Machining and Automation	3-1-0	4
ME 332	Advanced Manufacturing Process	3-0-0	3
ME 333	Process Control and Assurance Science	3-0-0	3
ME 334	Surface Engineering	3-0-0	3
ME 335	Metrology and Computer Aided Inspection	3-0-0	3
ME 336	Plastic Part Manufacturing and Tool Design	3-0-0	3
ME 430	Industrial Management	3-0-0	3
ME 431	Decision Modeling	3-0-0	3
ME 432	Non-Conventional Machining Processes	3-0-0	3
ME 433	Advanced Manufacturing Systems	3-0-0	3
ME 434	Computer Graphics for CAD/CAM	3-0-0	3
ME 435	Concurrent Engineering	3-0-0	3
ME 436	Entrepreneurship	3-0-0	3
ME 437	Welding Technology	3-0-0	3
ME 440	Industrial Management	3-0-0	3
ME 631	Production Technology	3-1-0	4
ME 635	Product Design for Manufacturing	3-1-0	4
ME 637	Production System & Computer Integrated Manufacturing	3-1-0	4
ME 641	Knowledge Based Systems in Manufacturing	3-1-0	4
ME 642	CNC Machine Tools and Automated Manufacturing	3-1-0	4
ME 645	Soft Computing for Intelligent Manufacturing	3-1-0	4

Sub discipline:	**Thermal Engineering Group**		
ME 250	Thermal Engineering	3-1-0	4
ME 251	Engineering Thermodynamics	3-1-0	4
ME 252	Thermal Problem in Electrical Systems	3-1-0	4
ME 253	Heat Transfer Problems in Electronics and Instrumentation	3-0-0	3
ME 254	Renewable Energy Systems	3-0-0	3
ME 351	Fluid Mechanics	3-1-0	4
ME 352	Fluid Dynamics and Hydraulic Machines	3-0-0	3
ME 353	Internal Combustion Engines	3-0-0	3
ME 354	Refrigeration and Air-conditioning	3-0-0	3
ME 355	Aircraft and Rocket Propulsion	3-0-0	3
ME 450	Computational Fluid Dynamics and Heat Transfer	3-0-0	3
ME 455	Nuclear Power Generation and Safety	3-0-0	3
Sub discipline:	**Laboratory Courses**		
ME 170	Machine Drawing and Solid Modeling	0-0-3	2
ME 271	Thermal Engineering Lab	0-0-3	2
ME 272	Mechanical Engineering Lab	0-0-3	2
ME 370	Heat Transfer and Refrigeration Lab.	0-0-3	2
ME 372	Fluid Mechanics & Fluid Machines Lab.	0-0-3	2
ME 373	Production Engineering Laboratory	0-0-3	2
ME 374	Computational Fluid Dynamics Lab.	0-0-3	2
ME 375	Internal Combustion Engines and Automobile Engineering Laboratory	0-0-3	2
ME 470	Design Engineering Lab.	0-0-3	2
Sub discipline:	**Project, Seminar and Special Courses**		
ME 280	Machine Element Design Practice – I	0-0-3	2
ME 380	Production Engineering Project	0-0-3	2
ME 381	Machine Element Design Practice – II	0-0-3	2
ME 391	Special Topic in Mechanical Engineering – I		3/4
ME 392	Special Topic in Mechanical Engineering – II		3/4
ME 393	Special Laboratory in Mechanical Engg – I	0-0-3	2
ME 394	Special Laboratory in Mechanical Engg – II	0-0-3	2
ME 395	Engineering Product Development Project – I	0-0-6	4
ME 396	Engineering Product Development Project – II	0-0-6	4
ME 470	Design Engineering Lab.	0-0-3	2
ME 480	Thermal Engineering Design Project	0-0-3	2
ME 481	Mechanical System Design Project	0-0-3	2
ME 483	Industrial Engineering Project	0-0-3	2
ME 491	Research Project – I	0-0-6	4
ME 492	Research Project – II	0-0-9	6

ME 493	Seminar and Technical Writing – I	0-0-3	2
ME 494	Seminar and Technical Writing – II	0-0-3	2
ME 495	Short term Industrial/Research Experience	0-0-0	2
ME 496	Comprehensive Viva-voce	0-0-0	2
ME 681	Special Topics in Mechanical Engineering – I	3-1-0	4
ME 682	Special Topics in Mechanical Engineering – II	3-1-0	4
ME 691	Short Term Industrial /Research Experience	0-0-0	2
ME 692	Comprehensive Viva Voce	0-0-0	4
ME 693	Research Project – III(Summer)	0-0-0	10
ME 694	Research Project – IV	0-0-0	10
ME 695	Research Project – V	0-0-30	20

DEPARTMENT OF METALLURGICAL & MATERIALS ENGINEERING

Curriculum of B. Tech (Metallurgical & Materials Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Mathematics – I		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			**15-5-15**	**30**

SECOND SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Mathematics – II		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithm		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 – II		0-0-3	2
	TOTAL			**15-5-15**	**30**

THIRD SEMESTER

Sl. No	Sub.Code	Subjects	L-T- P	Credits
1	MA 201	Mathematics – III	3-1-0	4
2	MM 201	Metallurgical Thermodynamics and Kinetics	3-1-0	4
3	MM 211	Science and Technology of Materials	3-1-0	4
4		Professional Elective – I		¾

5		HS & Open Elective – I		3-0-0	3
6	MA 270	Numerical Methods Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
7	EE 270	Electrical Engineering Laboratory - I	OR	0-0-3	2
	EC 270	Basic Electronics Laboratory			
8	MM 271	Mineral Dressing Laboratory.		0-0-3	2
9	MM 273	Polymer Laboratory.		0-0-3	2
TOTAL					**26/27**

FOURTH SEMESTER

Sl. No	Sub.Code	Subjects		L-T- P	Credits
1	MA 204	Mathematics – IV		3-1-0	4
2	MM 212	Casting and Solidification of Materials		3-1-0	4
3	MM 220	Unit Process of Extraction		3-1-0	4
4		Professional Elective – II		3-0-0	3
5		HS & Open Elective – II		3-0-0	3
6	HS 270	Language Laboratory	OR	0-0-3	2
	MA 270	Numerical Methods Laboratory			
7	EC 270	Electronics Laboratory	OR	0-0-3	2
	EE 270	Electrical Engineering Laboratory – I			
8	MM 270	Electro Metallurgy & Corrosion Lab.		0-0-3	2
9	MM 272	Characterization of Material Lab.		0-0-3	2
TOTAL					**26**

FIFTH SEMESTER

Sl. No	Sub.Code	Subjects	L-T- P	Credits
1	MM 311	Phase Transformation	3-1-0	4
2	MM 321	Ironmaking	3-1-0	4
3	MM 331	Deformation Theory of Metals	3-1-0	4
4		Professional Elective – III	3-0-0	3
5		HS & Open Elective – III	3-0-0	3
6	MM 371	Thermodynamics & Kinetics Lab.	0-0-3	2
7	MM 373	Mechanical Testing Lab.	0-0-3	2
8	MM 375	Metallography & Heat Treatment Lab.	0-0-3	2
9	WS 471	Advanced Welding and Foundry Practices	0-0-3	2
TOTAL				**26**

SIXTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	MM 314	Heat Treatment of Metallic Materials	3-1-0	4
2	MM 324	Steelmaking	3-1-0	4
3	MM 352	Material Characterization Techniques	3-1-0	4
4		Professional Elective – IV		¾

5		HS & Open Elective – IV	3-0-0	3
6	MM 370	Fuel Testing Lab.	0-0-3	2
7	MM 372	Thermal Analysis Lab.	0-0-3	2
8	MM 374	Structure Property Correlation project	0-0-3	2
9	MM 376	Computational Technique in Materials Engg. Lab.	0-0-3	2
TOTAL				**26/27**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MM 431	Mechanical Behaviour of Materials	3-1-0	4
2		Professional Elective – V		¾
3		Professional Elective – VI		¾
4		HS & Open Elective – V	3-0-0	3
5	MM 471	Composite Materials Lab.	0-0-3	2
6	MM 473	Design & Calculation Lab.	0-0-3	2
7	MM 491	Research Project – I	0-0-6	4
8	MM 493	Seminar & Technical Writing – I	0-0-3	2
9	MM 495	Short Term Industrial / Research Experience	0-0-3	2
TOTAL				**25/27**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1		Professional Elective – VII		¾
2		Professional Elective – VIII		¾
3		Professional Elective –IX		¾
4		HS & Open Elective – VI	3-0-0	3
5	MM 472	Modeling of Materials Processes	0-0-3	2
6	MM 492	Research Project – II	0-0-9	6
7	MM 494	Seminar & Technical Writing - II	0-0-3	2
8	MM 496	Comprehensive Viva- Voce	0-0-0	2
TOTAL				**24/27**

Curriculum of M. Tech Dual Degree (Specialization: Metallurgical & Materials Engineering)

[1st - 6th Semester curricula are common with B.Tech. Metallurgical & Materials Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MM 637	Mechanical Behaviour of Materials	3-1-0	4
2	MM 665	Powder Technology	3-1-0	4
3		Professional Elective – III (B.Tech.)	3-0-0	3
4		Professional Elective – IV (B.Tech.)	3-0-0	3
5		Professional Elective – V (B.Tech.)	3-0-0	3
6	MM 675	Process Metallurgy Laboratory	0-0-3	2

7	MM 673	Phase Transformation Laboratory	0-0-3	2
8	MM 491	Research Project – I	0-0-3	2
9	MM 493	Seminar and Technical Writing – I	0-0-3	2
10	MM 691	Short Term Industrial/Research Experience	0-0-0	2
		TOTAL		**27**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MM 634	Metallugical Failures: Detection and Analysis	3-1-0	4
2	MM 666	Computational Modeling of Materials	3-1-0	4
3		Professional Elective – VI (B.Tech.)	3-0-0	3
4		Professional Elective – VII (B.Tech.)	3-0-0	3
5		Professional Elective – VIII (B.Tech.)	3-0-0	3
6	MM 672	Experimental Techniques in Materials Engineering Laboratory	0-0-3	2
7	MM 674	Materials Science Laboratory	0-0-3	2
8	MM 494	Seminar and Technical Writing – II	0-0-3	2
9	MM 492	Research Project – II	0-0-3	2
		TOTAL	**15-2-12**	**25**

NINTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Electives – I (M.Tech.)	3-1-0	4
2		Professional Electives – II (M.Tech.)	3-1-0	4
3		Professional Electives – III (M.Tech.)	3-1-0	4
4	MM 687	Seminar and Technical Writing – III	0-0-3	2
5	MM 693	Research Project – III(Summer)	0-0-0	10
6	MM 694	Research Project – IV	0-0-0	10
		TOTAL	**9-3-3**	**34**

TENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MM 688	Seminar and Technical Writing – IV	0-0-3	2
2	MM 692	Comprehensive Viva	0-0-0	4
3	MM 695	Research Project – V	0-0-30	20
		TOTAL	**0-0-33**	**26**

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub.Code	Subject	L-T-P	Credits	Offered to
1	MM 215	Physics of Materials	3-1-0	4	#
2	MM 227	Fuel Technology	3-0-0	3	#
3	MM 256	Transport Phenomena	3-0-0	3	#
4	MM 257	Non – Metallic Materials	3-0-0	3	#

5	MM 258	Experimental Techniques	3-0-0	3	@
6	MM 268	Ceramic and Powder Metallurgy	3-0-0	3	#
7	MM 326	Non Ferrous Extraction	3-1-0	4	#
8	MM 336	Mechanical Working of Metallic Materials	3-1-0	4	#
9	MM 345	Nuclear Metallurgy	3-0-0	3	#
10	MM 356	Pollution in Metallurgical Industries and its Control	3-0-0	3	#
11	MM 357	Corrosion and Degradation of Materials and their Prevention	3-1-0	4	#
12	MM 359	Engineering Polymers and Composites	3-0-0	3	#
13	MM 391	Special Topic in Metallurgical & Mat. Engineering-I		3/4	#
14	MM 392	Special Topic in Metallurgical & Mat. Engineering – II		3/4	#
15	MM 393	Special Laboratory in Metallurgical & Mat. Engineering – I	0-0-3	2	#
16	MM 394	Special Laboratory in Metallurgical & Mat. Engineering – II	0-0-3	2	#
17	MM 395	Engineering Product Development Project – I	0-0-6	4	#
18	MM 396	Engineering Product Development Project – II	0-0-6	4	#
19	MM 416	Complex Ferrous & Non Ferrous Alloys	3-1-0	3	$
20	MM 426	Secondary Steelmaking	3-0-0	3	#
21	MM 427	Sponge Iron Technology	3-1-0	4	$
22	MM 428	Advances in Steelmaking	3-1-0	4	#
23	MM 435	Fracture Mechanics and Fatigue of Metals	3-1-0	4	#
24	MM 442	Advanced Materials	3-0-0	3	#
25	MM 446	Composite Materials	3-1-0	4	#
26	MM 449	Nanostructured Materials	3-0-0	3	#
27	MM 468	Joining of Metals	3-1-0	4	#
28	MM 606	X – Ray & Electron Microscopy	3-1-0	4	$
29	MM 615	Structure & Properties of Materials	3-1-0	4	$
30	MM 616	Alloy Steel Technology	3-1-0	4	$
31	MM 617	Physical Metallurgy of Advanced Metallic Materials	3-1-0	4	$
32	MM 618	Joining of Materials	3-0-0	3	$
33	MM 619	Physical Metallurgy of Alloy Steels	3-1-0	4	$
34	MM 623	Iron & Steel Making	3-1-0	4	$
35	MM 624	Advanced Foundry Technology	3-0-0	3	$
36	MM 625	Ferro – Alloy Technology	3-0-0	3	$
37	MM 628	Advances in Steel Making	3-1-0	4	$
38	MM 629	Advanced Extraction Processes	3-0-0	3	$
39	MM 635	Fracture Mechanics & Failure Analysis	3-1-0	4	$
40	MM 636	Advanced Processing of Materials	3-0-0	3	$

41	MM 638	Mechanical Working of Materials	3-1-0	4	$
42	MM 642	Advances in Materials Science & Engineering	3-0-0	3	$
43	MM 646	Composite Materials	3-1-0	4	$
44	MM 655	Transport Phenomena	3-0-0	3	$
45	MM 656	Corrosion and Degradation of Materials and their Prevention	3-0-0	3	$
46	MM 657	Environmental Pollution in Metallurgical Industries	3-0-0	3	$
47	MM 658	Texture of Materials	3-0-0	3	$
48	MM 681	Special Topics in Metallurgical and Material Engineering – I		3/4	$
49	MM 682	Special Topics in Metallurgical and Material Engineering – I		3/4	$
50	MM 683	Special Laboratory in Metallurgical and Material Engineering – I	0-0-3	2	$
51	MM 684	Special Laboratory in Metallurgical and Material Engineering – I	0-0-3	2	$
52	MM 686	Thermal plasma applications in Metallurgy	3-0-0	3	$
53	MM 689	Ultra-high strength materials: Processing, properties and applications	3-0-0	3	$
54	MM 690	Surface Engineering	3-0-0	3	$

Notes: *# (B.Tech. and all dual degree coursess), $(only for dual degree courses), @ (only for B.Tech courses)*

PROFESSIONAL ELECTIVES OFFERED BY OTHER DEPARTMENTS

Sl. No	Sub. Code	Subject	L-T-P	Credits	Offered To
1	CE 336	Advanced Environmental Engineering	3-1-0	4	#
2	CE 405	Disaster Management	3-0-0	3	#
3	CH 224	Polymer Science and Technology	3-0-0	3	@
4	CH 331	Polymer Science and Technology	3-0-0	3	$
5	CH 419	Transport Phenomena	3-1-0	4	#
6	CH 426	Coal Processing Technology	3-0-0	3	@
7	CH 432	Optimization Techniques in Processes Design	3-0-0	3	@
8	CR 325	Computational Materials Science	3-0-0	3	@
9	CR 416	Application of Refractories	3-1-0	4	@
10	CS 213	Principals of Programming Languages	3-1-0	4	#
11	CS 315	Optimization Techniques	3-1-0	4	#
12	CS 437	Soft Computing	3-0-0	3	#
13	CY 542	Biochemistry	3-1-0	4	#
14	CY 551	Polymer Chemistry	3-1-0	3	#
15	CY 565	Advanced Solid State Chemistry	3-1-0	4	#
16	CY 567	Nano Biotechnology	3-1-0	4	#
17	MA 522	Operation Research	3-1-0	4	#
18	MA 529	Information Theory	3-1-0	4	#

19	MA 553	Optimization Techniques	3-1-0	4	#
20	MA 556	Number Theory	3-1-0	4	#
21	ME 334	Surface Engineering	3-0-0	3	#
22	ME 356	Turbo - Machinery	3-0-0	3	#
23	ME 413	Experimental Stress Analysis	3-0-0	3	#
24	ME 415	Fundamentals of Tribology	3-0-0	3	#
25	PH 653	Advanced X – Ray structure Analysis	3-1-0	4	#

Note: *# (B.Tech. and all dual degree courses), $(only for dual degree courses), @ (only for B.Tech courses)*

COURSES OFFERED AS OPEN ELECTIVES

(Normally not offered to students of Metallurgical and Materials Engineering)

Sl. No	Sub.Code	Subject	L-T-P	Credits
1	MM 317	Material Technology	3-0-0	3
2	MM 318	Principle and Practice of Heat Treatments	3-0-0	3
3	MM 325	Ironmaking and Steelmaking	3-0-0	3
4	MM 358	Expermental Techniques in Materials Engineering	3-0-0	3
5	MM 408	Energy, Environment and Recycling	3-0-0	3
6	MM 448	Advanced Engineering Materials	3-0-0	3

SUMMARY OF COURSES

Sub Discipline:	Physical Metallurgy		
MM 211	Science and Technology of Materials	3-1-0	4
MM 212	Casting and Solidification of Materials	3-1-0	4
MM 215	Physics of Materials	3-1-0	4
MM 311	Phase Transformation	3-1-0	4
MM 314	Heat Treatment of Metallic Materials	3-1-0	4
MM 317	Materials Technology	3-0-0	4
MM 318	Principles and Practice of Heat Treatment	3-0-0	4
MM 416	Complex Ferrous & Non Ferrous Alloys	3-1-0	3
MM 606	X – Ray & Electron Microscopy	3-1-0	4
MM 615	Structure & Properties of Materials	3-1-0	4
MM 616	Alloy Steel Technology	3-1-0	4
MM 617	Physical Metallurgy of Advanced Metallic Materials	3-1-0	4
MM 618	Joining of Materials	3-0-0	3
MM 619	Physical Metallurgy of Alloy Steels	3-1-0	4

Sub Discipline:	Process Metallurgy		
MM 201	Metallurgical Thermodynamics and Kinetics	3-1-0	4
MM 220	Unit Process of Extraction	3-1-0	4
MM 227	Fuel Technology	3-0-0	3
MM 321	Ironmaking	3-1-0	4
MM 324	Steelmaking	3-1-0	4
MM 325	Iron and Steel Making	3-1-0	4

MM 326	Non Ferrous Extractions	3-1-0	4
MM 408	Energy, Environment and Recycling	3-0-0	3
MM 426	Secondary Steelmaking	3-0-0	3
MM 427	Sponge Iron Technology	3-1-0	4
MM 428	Advances in Steelmaking	3-1-0	4
MM 623	Iron & Steel Making	3-1-0	4
MM 624	Advanced Foundry Technology	3-0-0	3
MM 625	Ferro – Alloy Technology	3-0-0	3
MM 628	Advances in Steel Making	3-1-0	4
Sub Discipline:	**Mechanical Metallurgy**		
MM 331	Deformation Theory of Metals	3-1-0	4
MM 336	Mechanical Working of Metallic Materials	3-1-0	4
MM 431	Mechanical Behaviour of Materials	3-1-0	4
MM 435	Fracture Mechanics and Fatigue of Metals	3-1-0	4
MM 634	Metallugical Failures: Detection and Analysis	3-1-0	4
MM 635	Fracture Mechanics & Failure Analysis	3-1-0	4
MM 636	Advanced Processing of Materials	3-0-0	3
MM 637	Mechanical Behaviour of Materials	3-1-0	4
MM 638	Mechanical Working of Materials	3-1-0	4
Sub Discipline:	**Advanced Materials**		
MM 345	Nuclear Metallurgy	3-0-0	3
MM 442	Advanced Materials	3-0-0	3
MM 446	Composite Materials	3-1-0	4
MM 448	Advanced Engineering Materials	3-0-0	3
MM 449	Nanostructured Materials	3-0-0	3
MM 642	Advances in Materials Science & Engineering	3-0-0	3
MM 646	Composite Materials	3-1-0	4
Sub Discipline:	**Allied Courses**		
MM 256	Transport Phenomena	3-0-0	3
MM 257	Non – Metallic Materials	3-0-0	3
MM 268	Ceramic and Powder Metallurgy	3-0-0	3
MM 352	Material Characterization Techniques	3-1-0	4
MM266	Ceramic and Powder Metallurgy	3-0-0	3
MM 352	Material Characterization Techniques	3-1-0	4
MM 356	Pollution in Metallurgical Industries and its Control	3-0-0	3
MM 357	Corrosion and Degradation of Materials and their Prevention	3-1-0	4
MM 359	Engineering Polymers and Composites	3-0-0	3
MM 468	Joining of Metals	3-1-0	4
MM 655	Transport Phenomena	3-0-0	3

MM 656	Corrosion and Degradation of Materials and their Prevention	3-0-0	3
MM 657	Environmental Pollution in Metallurgical Industries	3-0-0	3
MM 665	Powder Technology	3-1-0	4
MM 666	Computational Modeling of Materials	3-1-0	4

Sub Discipline:	**Laboratory Courses**		
MM 270	Electro Metallurgy & Corrosion Laboratory	0-0-3	2
MM 271	Mineral Dressing Laboratory	0-0-3	2
MM 272	Characterization of Material Laboratory	0-0-3	2
MM 273	Polymer Laboratory	0-0-3	2
MM 370	Fuel Testing Lab.	0-0-3	2
MM 371	Thermodynamics & Kinetics Lab.	0-0-3	2
MM 372	Thermal Analysis Laboratory	0-0-3	2
MM 373	Mechanical Testing Lab.	0-0-3	2
MM 374	Structure Property Correlation project	0-0-3	2
MM 375	Metallography & Heat Treatment Lab.	0-0-3	2
MM 376	Computational Technique in Materials Engg. Lab	0-0-3	2
MM 471	Composite Materials Lab.	3-0-0	2
MM 472	Modeling of Materials Processes.	0-0-3	2
MM 473	Design & Calculation Lab.	0-0-3	2
MM 672	Experimental Techniques in Materials Engineering Laboratory	0-0-3	2
MM 673	Phase Transformation Laboratory	0-0-3	2
MM 674	Materials Science Laboratory	0-0-3	2
MM 675	Process Metallurgy Laboratory	0-0-3	2

Sub Discipline:	**Project, Seminar and Special Courses**		
MM 391	Special Topic in Metallurgical & Mat. Engineering - I		3/4
MM 392	Special Topic in Metallurgical & Mat. Engineering - II		3/4
MM 393	Special Laboratory in Metallurgical & Mat. Engineering - I	0-0-3	2
MM 394	Special Laboratory in Metallurgical & Mat. Engineering - II	0-0-3	2
MM 395	Engineering Product Development Project - I	0-0-6	4
MM 396	Engineering Product Development Project - II	0-0-6	4
MM 491	Research Project – I	0-0-6	4
MM 492	Research Project – II	0-0-9	6
MM 493	Seminar & Technical Writing – I	0-0-3	2
MM 494	Seminar & Technical Writing – II	0-0-3	2
MM 495	Short Term Industrial / Research Experience	0-0-0	2
MM 496	Comprehensive Viva- Voce	0-0-0	2
MM 681	Special Topics in Metallurgical and Material Engineering – I		3/4
MM 682	Special Topics in Metallurgical and Material Engineering – I		3/4
MM 683	Special Laboratory in Metallurgical and Material Engineering – I	0-0-3	2

MM 684	Special Laboratory in Metallurgical and Material Engineering – I	0-0-3	2
MM 686	Thermal plasma applications in Metallurgy	3-0-0	3
MM 687	Texture of Materials	3-0-0	3
MM 688	Ultra-high Strength materials: Processing, properties and applications	3-0-0	3
MM 690	Surface Engineering	3-0-0	3
MM 691	Short Term Industrial/ Research Experience	0-0-0	2
MM 692	Comprehensive Viva	0-0-0	4
MM 693	Research Project – III(Summer)	0-0-0	10
MM 694	Research Project - IV	0-0-0	10
MM 695	Research Project - V	0-0-30	20

DEPARTMENT OF MINING ENGINEERING

Curriculum of B. Tech (Mining Engineering)

FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 101	Mathematics – I		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				**15-5-15**	**30**

SECOND SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 102	Mathematics – II		3-1-0	4
2	PH 102	Physics – II		3-1-0	4
3	CS 102	Data Structures and Algorithm		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 – II		0-0-3	2
	TOTAL			**15-5-15**	**30**

THIRD SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	MA 201	Mathematics – III	3-1-0	4
2	MN 201	Mine Development	3-1-0	4
3	CE 203	Mechanics of Solids	3-0-0	3
4		Professional Elective – I	3-0-0	3

5		HS & Open Elective – I		3-0-0	3
6	MA 270	Mathematics – III Laboratory	OR	0-0-3	2
	HS 270	Language Laboratory			
7	EE 270	Electrical Engineering Laboratory	OR	0-0-3	2
	EC 270	Electronics Laboratory			
8	MN 273	Mining Geology & Exploration Laboratory		0-0-3	2
9	CE 273	Mechanics of Solids Laboratory		0-0-3	2
		TOTAL			**25**

FOURTH SEMESTER

Sl. No	Sub. Code	Subjects		L-T- P	Credits
1	MA 204	Mathematics – IV		3-1-0	4
2	MN 202	Mine Surveying		3-1-0	4
3		Professional Elective – II		3-0-0	3
4		Professional Elective – III		3-0-0	3
5		HS & Open Elective – II		3-0-0	3
6	HS 270	Language Laboratory	OR	0-0-3	2
	MA 270	Mathematics – III Laboratory			
7	EC 270	Electronics Laboratory	OR	0-0-3	2
	EE 270	Electrical Engineering Laboratory			
8	MN 274	Mining Machinery Laboratory		0-0-3	2
9	MN 271	Mine Surveying Laboratory		0-0-3	2
		TOTAL			**25**

FIFTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	MN 311	Surface Mining Technology	3-1-0	4
2	MN 321	Rock Mechanics	3-1-0	4
3		Professional Elective – IV	3-0-0	3
4		Professional Elective – V	3-0-0	3
5		HS & Open Elective – III	3-0-0	3
6	MN 371	Rock Mechanics Laboratory	0-0-3	2
7	MN 373	Mineral Processing Technology Laboratory	0-0-3	2
8	MN 375	Material Handling Systems Laboratory	0-0-3	2
9	MN 377	Solid Fuel Technology Laboratory	0-0-3	2
		TOTAL		**25**

SIXTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MN 330	Mine Ventilation	3-1-0	4
2	MN 313	Underground Mining Technology	3-1-0	4
3		Professional Elective – VI	3-1-0	4
4		Professional Elective – VII	3-1-0	4

5		HS & Open Elective – IV	3-0-0	3
6	MN 370	Mine Ventilation Laboratory	0-0-3	2
7	MN 372	Computer Application in Mining Laboratory	0-0-3	2
8	MN 374	Geomechanics Laboratory	0-0-3	2
9	MN 376	Model preparation Laboratory	0-0-3	2
TOTAL				**27**

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MN 431	Mine Environmental Engineering	3-1-0	4
2	MN 441	Mine Legislation and Safety Engineering	3-1-0	4
3		Professional Elective – VIII	3-1-0	4
4		HS & Open Elective – V	3-0-0	3
5	MN 471	Mine Environmental Engineering Laboratory	0-0-3	2
6	MN 473	Simulation and Modeling of Mining systems Laboratory	0-0-3	2
7	MN 491	Research Project – I	0-0-6	4
8	MN 493	Seminar and Technical Writing – I	0-0-3	2
9	MN 495	Short Term Industrial / Research Experience	0-0-3	2
TOTAL				**27**

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	MN 400	Mine Planning	3-1-0	4
2		Professional Elective – IX	3-1-0	4
3		Professional Elective – X	3-1-0	4
4		HS & Open Elective – VI	3-0-0	3
5	MN 472	Mine Planning and Design Laboratory	0-0-3	2
6	MN 492	Research Project – II	0-0-9	6
7	MN 494	Seminar and Technical Writing – II	0-0-3	2
8	MN 496	Comprehensive Viva Voce	0-0-0	2
TOTAL				**27**

Curriculum of M. Tech Dual Degree (Specialisation: Mining Engineering)

[1st - 6th Semester curricula are common with B.Tech. Mining Engineering]

SEVENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MN 623	Advance Environmental Engineering	3-1-0	4
2	MN 641	Mine Legislation & Safety Engineering	3-1-0	4
3		Profession Elective – VIII (B.Tech.)	3-0-0	3
4		Profession Electives – IX (B.Tech.)	3-0-0	3
5		Profession Electives – X (B.Tech.)	3-0-0	3
6	MN 671	Rock Excavation Engineering Laboratory	0-0-3	2
7	MN 673	Mine Engineering Laboratory – II	0-0-3	2

8	MN 491	Research Project – I	0-0-3	2
9	MN 493	Seminar and Technical Writing – I	0-0-3	2
10	MN 691	Short Term Industrial/Research Experience	0-0-0	2
TOTAL				27

EIGHTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	MN 600	Mine Planning	3-1-0	4
2	MN 602	Mine Management	3-1-0	4
3		Professional Elective – XI (B.Tech.)	3-0-0	3
4		Professional Elective – XII (B.Tech.)	3-0-0	3
5		Professional Elective – XIII (B.Tech.)	3-0-0	3
6	MN 672	Advance Environmental Engineering Laboratory	0-0-3	2
7	MN 674	Mining Engineering Laboratory – II	0-0-3	2
8	MN 492	Research Project – II	0-0-3	2
9	MN 494	Seminar and Technical Writing – II	0-0-3	2
TOTAL				25

NINTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1		Professional Electives – I (M.Tech.)	3-1-0	4
2		Professional Electives – II (M.Tech.)	3-1-0	4
3		Professional Electives – III (M.Tech.)	3-1-0	4
4	MN 687	Seminar and Technical Writing – III	0-0-3	2
5	MN 693	Research Project - III	0-0-0	10
6	MN 694	Research Project – IV	0-0-0	10
TOTAL				34

TENTH SEMESTER

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MN 688	Seminar and Technical Writing – IV	0-0-3	2
2	MN 692	Comprehensive Viva	0-0-0	4
3	MN 695	Research Project - V	0-0-30	20
TOTAL				26

LIST OF PROFESSIONAL ELECTIVES

Sl. No	Sub. Code	Subject	L-T- P	Credits	Offered to
1	MN 204	Mining Machinery	3-0-0	3	#
2	MN 205	Mineral Exploration	3-0-0	3	#
3	MN 207	Mining Geology	3-0-0	3	#
4	MN 208	Geostatistics	3-0-0	3	#
5	MN 232	Solid Fuel Technology	3-0-0	3	#
6	MN 301	System Engineering	3-0-0	3	#

7	MN 302	Mine Economics	3-1-0	4	#
8	MN 303	Material Handling Systems	3-0-0	3	#
9	MN 304	Computer Application in Mining	3-1-0	4	#
10	MN 305	Mineral Processing Technology	3-0-0	3	#
11	MN 322	Geomechanics	3-1-0	4	#
12	MN 324	Strata Control Technology	3-1-0	4	#
13	MN 325	Ground Control Instrumentation	3-1-0	4	#
14	MN 332	Remote Sensing and Its Application	3-1-0	4	#
15	MN 391	Special Topic in Mining Engineering – I		3/4	#
16	MN 392	Special Topic in Mining Engineering – II		3/4	#
17	MN 393	Special Laboratory in Mining Engineering – I	0-0-3	2	#
18	MN 394	Special Laboratory in Mining Engineering – II	0-0-3	2	#
19	MN 395	Engineering Product Development Project – I	0-0-6	4	#
20	MN 396	Engineering Product Development Project – II	0-0-6	4	#
21	MN 410	Tunneling	3-1-0	4	#
22	MN 411	Advanced Surface Mining	3-1-0	4	#
23	MN 412	Mining of Deep Seated Deposits	3-1-0	4	#
24	MN 413	Advanced Coal Mining	3-1-0	4	#
25	MN 414	Rock Mechanics Application to Environmental Problems	3-0-0	3	#
26	MN 415	Advanced Metaliferrous Mining	3-1-0	4	#
27	MN 421	Rock Slope Technology	3-0-0	3	#
28	MN 435	Eco-friendly Mining	3-1-0	4	#
29	MN 436	Environmental Pollution and Control in Mines	3-1-0	4	#
30	MN 442	Mine Fires and spontaneous heating	3-1-0	4	#
31	MN 451	Mine Management	3-1-0	4	#
32	MN 603	Geo – aspects Management of low and high risk solid byproducts	3-0-0	3	$
33	MN 606	Strata Control Technology	3-1-0	4	$
34	MN 607	Ground Control Instrumentation	3-1-0	4	$
35	MN 608	Tunneling	3-1-0	4	$
36	MN 609	Advanced Surface Mining	3-1-0	4	$
37	MN 610	Mining of Deep Seated Deposits	3-1-0	4	$
38	MN 611	Advanced Coal Mining	3-1-0	4	$
39	MN 614	Rock Mechanics Application to Environmental Problems	3-1-0	4	$
40	MN 620	Application of Artificial Intelligence in Mining	3-1-0	4	$
41	MN 632	Environmental Management	3-1-0	4	$
42	MN 633	Mine Fires and spontaneous Heating	3-1-0	4	$
43	MN 635	Advanced Mine Ventilation	3-1-0	4	$
44	MN 637	Noise Impact Assessment And Control	3-1-0	4	$
45	MN 638	Hazardous Waste Management	3-1-0	4	$

46	MN 639	Safety Risk Assessment & Management	3-1-0	4	$
47	MN 640	Eco Friendly Mining	3-1-0	4	$
48	MN 642	Hydrogeology	3-1-0	4	$
49	MN 643	Remote Sensing & GIS for Mining Engineering	3-1-0	4	$

Notes: *# (B.Tech. and all dual degree courses), $(only for dual degree courses)*

PROFESSIONAL ELECTIVES FROM OTHER DEPARTMENTS

Sl. No	Sub. Code	Subject	L-T- P	Credits	Offered to
1	CE 301	Advanced Surveying	3-1-0	4	@
2	CE 316	Advanced Mechanics of Solids	3-1-0	4	#
3	CE 318	Finite Element Method	3-1-0	4	#
4	CE 333	Environmental Impact Assessment	3-1-0	4	#
5	CE 336	Advanced Environmental Engineering	3-1-0	4	#
6	CE 421	Ground Improvement Techniques	3-0-0	3	#
7	CE 425	Environmental Geotechnics	3-0-0	3	#
8	CH 228	Treatment of Industrial Effluents	3-0-0	3	#
9	CS 315	Optimization Techniques	3-1-0	4	#
10	CS 434	Image Processing	3-0-0	3	#
11	CS 435	Artificial Intelligence	3-0-0	3	#
12	CS 437	Soft Computing	3-0-0	3	#
13	HS 320	Human Resource Management	3-0-0	3	#
14	MA 420	Operations Research	3-1-0	4	#
15	MA 421	Stochastic Processes	3-1-0	4	#
16	ME 413	Experimental stress analysis	3-0-0	3	#
17	ME 440	Industrial Management	3-0-0	3	@
18	MM 268	Ceramic and Powder Metallurgy	3-0-0	3	#

****Note:*** *# (B.Tech. and all dual degree courses), $(only for dual degree courses), @ (only for B.Tech courses)*

COURSES OFFERED AS OPEN ELECTIVES

(Normally not offered to students of Mining Engineering)

Sl. No	Sub. Code	Subject	L-T- P	Credits	Non Eligible Branches
1	MN 203	Basic Surveying	3-0-0	3	CE
2	MN 206	Introductory Mining Technology	3-0-0	3	-
3	MN 323	Rock Engineering	3-0-0	3	CE
4	MN 336	Solid Fuels and Clean Coal Technology	3-0-0	3	-
5	MN 433	Environmental Impact Assessment	3-0-0	3	CH, CE
6	MN 438	Solid Waste Management	3-0-0	3	CE, CH, MM

SUMMARY OF COURSES

Sub Discipline:	Non-specific Subjects		
MN 201	Mine Development	3-1-0	4

MN 202	Mine Surveying	3-1-0	4
MN 203	Basic Surveying	3-0-0	3
MN 204	Mining Machinery	3-0-0	3
MN 205	Mineral Exploration	3-0-0	3
MN 206	Introductory Mining Technology	3-0-0	3
MN 207	Mining Geology	3-0-0	3
MN 208	Geostatistics	3-0-0	3
MN 301	System Engineering	3-0-0	3
MN 302	Mine Economics	3-1-0	4
MN 303	Material Handling Systems	3-0-0	3
MN 304	Computer Application in Mining	3-1-0	4
MN 305	Mineral Processing Technology	3-0-0	3
MN 400	Mine Planning	3-1-0	4
MN 451	Mine Management	3-1-0	4
MN 600	Mine Planning	3-1-0	4
MN 602	Mine Management	3-1-0	4
MN 603	Geo – aspects Management of low and high risk solid byproducts	3-0-0	3
MN 606	Strata Control Technology	3-1-0	4
MN 607	Ground Control Instrumentation	3-1-0	4
MN 608	Tunneling	3-1-0	4
MN 609	Advanced Surface Mining	3-1-0	4

Sub Discipline:	**Geomechanics**		
MN 311	Surface Mining Technology	3-1-0	4
MN 313	Underground Mining Technology	3-1-0	4
MN 321	Rock Mechanics	3-1-0	4
MN 322	Geomechanics	3-1-0	4
MN 323	Rock Engineering	3-1-0	4
MN 324	Strata Control Engineering	3-1-0	4
MN 325	Ground Control Techniques	3-1-0	4
MN 410	Tunneling	3-1-0	4
MN 411	Advanced Surface Mining	3-1-0	4
MN 412	Mining of Deep Seated Deposits	3-1-0	4
MN 413	Advanced Coal Mining	3-1-0	4
MN 414	Rock Mechanics Application to Environmental Problems	3-0-0	3
MN 415	Advanced Metaliferrous Mining	3-1-0	4
MN 421	Rock Slope Technology	3-1-0	4
MN 610	Mining of Deep Seated Deposits	3-1-0	4
MN 611	Advanced Coal Mining	3-1-0	4
MN 614	Rock Mechanics Application to Environmental Problems	3-1-0	4
MN 616	Advanced Metaliferrous Mining	3-1-0	4

Sub Discipline:	Environment		
MN 232	Solid Fuel Technology	3-0-0	3
MN 331	Solid Fuel Technology	3-0-0	3
MN 330	Mine Ventilation	3-1-0	4
MN 332	Remote Sensing and Its Application	3-1-0	4
MN 336	Solid Fuels and Clean Coal Technology	3-0-0	3
MN 431	Mine Environmental Engineering	3-1-0	4
MN 433	Environmental Impact Assessment	3-0-0	3
MN 435	Eco-friendly Mining	3-1-0	4
MN 436	Environmental Pollution and Control in Mines	3-1-0	4
MN 438	Solid Waste Management	3-0-0	3
MN 441	Mine Legislation and Safety Engineering	3-1-0	4
MN 442	Mine Fires and spontaneous heating	3-1-0	4
MN 451	Mine Management	3-1-0	4
MN 620	Application of Artificial Intelligence in Mining	3-1-0	4
MN 623	Advanced Environmental Engg.	3-1-0	4
MN 632	Environmental Management	3-1-0	4
MN 633	Mine Fires and spontaneous Heating	3-1-0	4
MN 635	Advanced Mine Ventilation	3-1-0	4
MN 637	Noise Impact Assessment And Control	3-1-0	4
MN 638	Hazardous Waste Management	3-1-0	4
MN 639	Safety Risk Assessment & Management	3-1-0	4
MN 640	Ecofriendly Mining	3-1-0	4
MN 641	Mine Legislation & Safety Engineering	3-1-0	4
MN 642	Hydrogeology	3-1-0	4
MN 643	Remote Sensing & GIS for Mining Engineering	3-1-0	4

Sub Discipline:	Laboratory Courses		
MN 271	Mine Surveying Laboratory	0-0-3	2
MN 273	Mining Geology & Exploration Laboratory	0-0-3	2
MN 274	Mining Machinery Laboratory	0-0-3	2
MN 370	Mine Ventilation Laboratory	0-0-3	2
MN 371	Rock Mechanics Laboratory	0-0-3	2
MN 372	Computer Application in Mining Laboratory	0-0-3	2
MN 373	Mineral Processing Technology Laboratory	0-0-3	2
MN 374	Geomechanics Laboratory	0-0-3	2
MN 375	Material Handling Systems Laboratory	0-0-3	2
MN 376	Model preparation Laboratory	0-0-3	2
MN 377	Solid Fuel Technology Laboratory	0-0-3	2
MN 471	Mine Environmental Engineering Laboratory	0-0-3	2
MN472	Mine Planning and Design Laboratory	0-0-3	2

MN 473	Simulation and Modeling of Mining Systems Laboratory	0-0-3	2
MN 671	Rock Excavation Engineering Laboratory	0-0-3	2
MN 672	Advance Environmental Engineering Laboratory	0-0-3	2
MN 673	Mine Engineering Laboratory - II	0-0-3	2
MN 674	Mining Engineering Laboratory – II	0-0-3	2

Sub Discipline:	**Project, Seminar and Special Courses**		
MN 391	Special Topic in Mining Engineering – I		3/4
MN 392	Special Topic in Mining Engineering – II		3/4
MN 393	Special Laboratory in Mining Engg – I	0-0-3	2
MN 394	Special Laboratory in Mining Engg – II	0-0-3	2
MN 395	Engineering Product Development Project - I	0-0-6	4
MN 396	Engineering Product Development Project - II	0-0-6	4
MN 491	Research Project – I	0-0-3	2
MN 492	Research Project – II	0-0-3	2
MN 493	Seminar and Technical Writing – I	0-0-3	2
MN 494	Seminar and Technical Writing – II	0-0-3	2
MN 495	Short Term Industrial/Research Experience	0-0-0	2
MN 496	Comprehensive Viva Voce	0-0-0	2
MN 687	Seminar and Technical Writing – III	0-0-3	2
MN 688	Seminar and Technical Writing – IV	0-0-3	2
MN 691	Short Term Industrial/Research Experience	0-0-0	2
MN 692	Comprehensive Viva - Voce	0-0-0	4
MN 693	Research Project – III(Summer)	0-0-0	10
MN 694	Research Project - IV	0-0-0	10
MN 695	Research Project - V	0-0-30	20

Curricula and Syllabi

Bachelor of Architecture (B.Arch)

2014-15 onwards

Department of Planning and Architecture
National Institute of Technology Rourkela
May 2014

Department of Planning and Architecture

1. Vision

To provide every citizen of India a proper habitat for living and work with state of the art facilities and services ensuring minimal damage to the environment

2. Mission

I. To produce socially responsible architects who would not only be industry leading technocrats in the field of design, implementation and management of human habitats and ancillary services but also experts in application of state-of-art technologies in the fields of illumination, acoustics, energy and materials.
II. To create planners for 21^{st} century India with emphasis on planning for the changing socio-economic needs of the society in an evolving economy. The planners thus groomed would be capable technocrats and efficient urban managers.
III. To carry out relevant research in all aspects of planning and architecture that have reference to contemporary living with emphasis on functionality, safety, comfort, conservation, and aesthetics.

3. Programme Name e.g. B.Tech, M.Tech, Control & Automation etc.

I. **Bachelor of Architecture** (**B.Arch**)

4. PEOs

I. To equip students with knowledge of engineering, arts and aesthetics for pursuing studies in Architecture.
II. To impart understanding on the relationship between man, the built space, the natural environment and their spatial implications.
III. To provide knowledge on the latest engineering and technological aspects of building sciences including evolving areas like illumination, acoustics, building services, building automation, etc.
IV. To impart required skills to deal with users' requirements through proper investigation and creation of design problems and addressing them through suitable technical, aesthetic skills and compliance with regulatory requirements.

5. POs

i. Graduates will demonstrate an ability to conceive, frame, analyze and provide design solutions to architectural problems
ii. Graduates will demonstrate ability to work in a multidisciplinary environment and incorporate these knowledge to improve design solutions
iii. Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
iv. Graduates will demonstrate knowledge of professional and ethical responsibilities.
v. Graduates will be able to represent and communicate effectively using latest media technologies in both verbal and written form.
vi. Graduates will show the understanding of impact of architectural solutions on the society and also will be aware of contemporary issues.

vii. Graduates will get necessary training to go in for higher academic programmes or for employment in Industry.

6. Curriculum of B. Arch (Batch of 2014 and onwards)

FIRST SEMESTER

SL NO	SUB CODE	SUBJECTS	LTP	CREDITS
1	MA 101	Core Course – I: Mathematics-I	3-1-0	4
2	HS 311	Core Course – II: Communicative English	3-0-0	3
3	PA161	Core Course – III: Basic Design	3-0-0	3
4	PA171	Core Course – IV: History of Architecture-I	3-0-0	3
5	CE 100 CE 130	Engineering Mechanics OR Environmental and safety engineering	3-1-0	4
6	PA111	Laboratory-I: Architectural Design-I	0-0-3	2
7	PA121	Laboratory-II: Architectural Graphics-I	0-0-3	2
8	CS 171	Laboratory-III: Computing Laboratory-I	0-0-3	2
9	WS 171	Laboratory-IV: Workshop Practice-I	0-0-3	2
10	EA 171	Extra Academic Activity-I	0-0-3	2
TOTAL			15-2-15	27

SECOND SEMESTER

SL NO	SUB CODE	SUBJECTS	LTP	CREDITS
1	MA102	Core Course – V: Mathematics – II	3-1-0	4
2	PA176	Core Course – VI: History of Architecture-II	3-0-0	3
3	PA132	Core Course – VII: Building Construction-I	3-0-0	3
4	PA142	Core Course – VIII: Building Materials-I	3-0-0	3
5	CE 100 CE 130	Engineering Mechanics OR Environmental and Safety Engineering	3-1-0	4
6	PA112	Laboratory-V: Architectural Design-II	0-0-3	2
7	PA122	Laboratory-VI: Architectural Graphics-II	0-0-3	2
8	PA134	Laboratory-VII: Building Construction Studio-I	0-0-3	2
9	PA162	Laboratory-VIII: Visual Arts-I	0-1-3	3
10	EA 172	Extra Academic Activity-II	0-0-3	2
11	PA182	Study Tour-I	0-0-0	2
TOTAL			15-3-15	30

THIRD SEMESTER

SL NO	SUB CODE	SUBJECTS	LTP	CREDITS
1	CE 203	Core Course – IX: Mechanics of Solids	3-1-0	4
2	PA271	Core Course – X: History of Architecture-III	3-0-0	3
3	PA231	Core Course – XI: Building Construction-II	3-0-0	3
4	PA241	Core Course – XII: Building Materials-II	3-0-0	3
5	PA281	Core Course – XIII: Climate Responsive Architecture	3-1-0	4
6	PA211	Laboratory-IX: Architectural Design-III	0-0-6	4
7	PA221	Laboratory-X: Architectural Graphics-III	0-0-3	2
8	PA233	Laboratory-XI: Building Construction Studio-II	0-0-3	2
9	PA261	Laboratory-XII: Visual Arts-II	0-1-3	3
10	PA283	Laboratory-XIII: Non-graphic Computer Application	0-0-3	2
TOTAL			15-3-18	30

FOURTH SEMESTER

SL NO	SUB CODE	SUBJECTS	LTP	CREDITS
1	CE 212	Core Course – XIV: Structural Analysis	3-1-0	4
2	PA272	Core Course – XV: History of Architecture-IV	3-0-0	3
3	PA232	Core Course – XVI: Building Construction-III	3-0-0	3
4	PA282	Core Course – XVII: Building Bye Laws and Codes of Practices	3-0-0	3
5	PA	Professional Elective-I	3-0-0	3
6	PA212	Laboratory-XIV: Architectural Design-IV	0-0-6	4
7	PA222	Laboratory-XV: Computer Aided Design and Simulation-I	0-0-3	2
8	PA234	Laboratory-XVI: Building Construction Studio-III	0-0-3	2
9	CE 274	Laboratory-XVII: Surveying Field work	0-0-3	2
10	PA284	Laboratory-XVIII: Model Making Workshop	0-0-3	2
11	PA286	Study Tour-II	0-0-0	2
TOTAL			15-1-18	30

FIFTH SEMESTER

SL NO	SUB CODE	SUBJECTS	LTP	CREDITS
1	CE 311	Core Course – XVIII: Reinforced Concrete Design	3-1-0	4
2	CE 401	Core Course – XIX: Estimation and Construction Management	3-1-0	4
3	PA351	Core Course – XX: Building Services-I	3-0-0	3
4	PA	Professional Elective-II	3-0-0	3
5		Open Elective I- HS and Open Elective	3-0-0	3
6	PA	Professional Elective-III (Interior, Landscape, Urban Design)	0-1-3	3
7	PA311	Laboratory-XIX: Architectural Design-V	0-0-9	6
8	PA321	Laboratory-XX: Computer Aided Design and Simulation-II	0-0-3	2
9	PA331	Laboratory-XXI: Working Drawing – I	0-0-3	2
TOTAL			15-3-18	30

SIXTH SEMESTER

SL NO	SUB CODE	SUBJECTS	LTP	CREDITS
1	CE 312	Core Course – XXI: Design of Steel Structures	3-1-0	4
2	PA352	Core Course – XXII: Building Services-II	3-0-0	3
3	PA382	Core Course – XXIII: Theory of Design	3-1-0	4
4	PA384	Core Course – XXIV: Human Settlements and Vernacular Architecture	3-0-0	3
5		Open Electives-II: HS and open elective	3-0-0	3
6	PA312	Laboratory-XXII: Architectural Design-VI	0-0-9	6
7	PA322	Laboratory-XXIV: Computer Aided Design & Simulation – III	0-0-3	2
8	PA332	Laboratory-XXIII: Working Drawing – II	0-0-3	2
9	PA386	Laboratory-XXV: Estimation, Costing and Specifications Lab	0-0-3	2
TOTAL			15-2-18	29

SEVENTH SEMESTER

SL NO	SUB CODE	SUBJECTS	LTP	CREDITS
1		Core Course – XXV: Advanced Structural Design and Systems	3-0-0	3
2	PA441	Core Course – XXVI: Advanced Building Materials	3-0-0	3
3	PA481	Core Course – XXVII: Professional Practice-I	3-0-0	3
4	PA	Professional Elective-IV	3-0-0	3
5	PA	Professional Elective-V	3-0-0	3
6	PA411	Laboratory-XXVI: Architectural Design-	0-0-12	8

		VII		
7	PA431	Laboratory-XXVII: Advanced Building Construction Studio	0-0-3	2
8	PA451	Laboratory-XXVIII: Advanced Building Services	0-0-3	2
9	PA413	Research Project-I (Dissertation)	0-0-0	4
10		Seminar & Technical Writing-I	0-0-0	2
TOTAL			15-0-18	33

EIGHTH SEMESTER

SL NO	SUB CODE	SUBJECTS	LTP	CREDITS
1	PA482	Core Course – XXVIII: Professional Practice-II	3-0-0	3
2	PA	Professional Elective-VI	3-0-0	3
3	PA	Professional Elective-VII	3-0-0	3
4	PA412	Research Project-II (Thesis)	0-0-0	12
5	PA414	Comprehensive Viva-voce	0-0-0	2
6		Seminar & Technical Writing-II	0-0-0	2
TOTAL			9-0-0	25

NINTH SEMESTER

SL NO	SUB CODE	SUBJECTS	LTP	CREDITS
1	PA511	Professional Training-I	0-0-0	4
2	PA513	Documentation of Innovative Details-I	0-0-0	2
3	PA515	Field Observation-I	0-0-0	2
4	PA517	Site Supervision-I	0-0-0	2
5	PA519	Critical Appraisal-I	0-0-0	2
TOTAL			0-0-0	12

TENTH SEMESTER

SL NO	SUB CODE	SUBJECTS	LTP	CREDITS
1	PA512	Professional Training-II	0-0-0	4
2	PA514	Documentation of Innovative Details-II	0-0-0	2
3	PA516	Field Observation-II	0-0-0	2
4	PA518	Site Supervision-II	0-0-0	2
5	PA510	Critical Appraisal-II	0-0-0	2
6	PA580	Academic Project Documentation	0-0-0	4
TOTAL			0-0-0	16

- Professional Training-I and II to be done for 18 weeks.

- The student has the choice to either do Professional Training-II with the same Architectural firm under which he/she did Professional Training-I or to do it in another firm for more exposure to different practice.
- Academic Project Documentation means compilation of all the academic projects including Thesis and Professional Training.

LIST OF PROFESSIONAL ELECTIVES				
SL NO	**SUB CODE**	**SUBJECTS**	**LTP**	**CREDITS**
1	PA101	Building Acoustics	3-0-0	3
2	PA103	Building Illumination	3-0-0	3
3	PA105	Housing	3-0-0	3
4	PA107	Urban Design	0-1-3	3
5	PA108	Interior Design	0-1-3	3
6	PA109	Landscape design	0-1-3	3
7	PA201	Construction Management	3-0-0	3
8	PA202	Urban and Regional Planning	3-0-0	3
9	PA203	Architectural Conservation	3-0-0	3
10	PA204	Disaster Management	3-0-0	3
11	PA205	Architectural Journalism	3-0-0	3
12	PA206	Theatre/Film Set Design	3-0-0	3
13	PA207	Expert Systems Advanced Computing	3-0-0	3
14	PA208	Marketing Skills	3-0-0	3
15	PA209	Building Systems Integration	3-0-0	3
16	PA301	Visual Communication	3-0-0	3
17	PA302	Sustainable Architecture	3-0-0	3
18	PA303	Energy Conscious Architecture	3-0-0	3
19	PA304	Intelligent Buildings	3-0-0	3
20	PA305	Modular Coordination	3-0-0	3
21	PA306	Art in Architecture	3-0-0	3
22	PA307	Environmental studies	3-0-0	3

DEPARTMENT OF BIOTECHNOLOGY AND MEDICAL ENGINEERING

DETAILED SYLLABI OF COURSES

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	BM 201	Anatomy and Physiology	3-0-0	3
2	BM 202	Clinical Science	3-1-0	4
3	BM 203	Clinical Biochemistry	3-0-0	3
4	BM 205	Clinical Microbiology	3-0-0	3
6	BM 232	Biofluid Mechanics	3-1-0	4
7	BM 234	Biothermodynamics	3-0-0	3
8	BM 242	Immunology	3-0-0	3
9	BM 244	Cell and Molecular Biology	3-0-0	3
10	BM252	Bioenergetics & Metabolism	3-0-0	3
11	BM 254	Bioprocess Calculation	3-0-0	3
12	BM 256	Enzymology	3-0-0	3
13	BM 271	Anatomy and Physiology Laboratory	0-0-3	2
14	BM 272	Biofluid Mechanics Laboratory	0-0-3	2
15	BM 273	Clinical Biochemistry Laboratory	0-0-3	2
16	BM 274	Analytical Biotechnology Laboratory	0-0-3	2
17	BM 275	Clinical Microbiology Laboratory	0-0-3	2
18	BM 282	Clinical Science Laboratory	0-0-3	2
19	BM 311	Medical Signal and Signal Processing	3-1-0	4
20	BM 312	Biomedical Instrumentation	3-1-0	4
21	BM 313	Biological Control System	3-0-0	3
22	BM 314	Biomedical Image Processing	3-1-0	4
23	BM 315	Laser & Fiber Optics in Medicine	3-0-0	3
24	BM 316	Biosensors and Biotransducers	3-0-0	3
25	BM 317	Biomedical Engineering	3-0-0	3
26	BM 318	Medical Instrumentation	3-0-0	3
27	BM 321	Biomaterials	3-1-0	4
28	BM 322	Biopolymers	3-0-0	3
29	BM 324	Surface Engineering of Biomaterials	3-0-0	3
30	BM 331	Bioheat and Mass Transfer	3-1-0	4
31	BM 332	Biomechanics	3-0-0	3
32	BM 341	Genetic Engineering	3-1-0	4
33	BM 342	Applied Cell Biology	3-0-0	3
34	BM 343	Bioinformatics	3-0-0	3
35	BM 345	Animal Tissue Culture	3-0-0	3
36	BM 352	Biochemical Engineering	3-1-0	4
37	BM 353	Pharmaceutical Technology	3-0-0	3
38	BM 354	Bioseparation	3-1-0	4
39	BM 356	Bioinstrumentation and Process Control	3-1-0	4
40	BM 358	Bioreactor Analysis & Design	3-0-0	3

41	BM 361	Agricultural Biotechnology	3-0-0	3
42	BM 362	Plant Tissue Culture	3-0-0	3
43	BM 370	Bioinformatics Laboratory	0-0-3	2
44	BM 371	Cell and Molecular Engineering Laboratory	0-0-3	2
45	BM 372	Bioseparation Laboratory	0-0-3	2
46	BM 373	Environmental Biotechnology Laboratory	0-0-3	2
47	BM 374	Biochemical Engineering Laboratory	0-0-3	2
48	BM 375	Bioheat and Mass transfer Laboratory	0-0-3	2
49	BM 376	Bioprocess Instrumentation Laboratory	0-0-3	2
50	BM 378	Animal Cell Culture and Immunotechnology Laboratory	0-0-3	2
51	BM 381	Biomaterial Laboratory	0-0-3	2
52	BM 382	Biomedical Image Processing Laboratory	0-0-3	2
53	BM 383	Biomedical Signal Processing Laboratory – I	0-0-3	2
54	BM 384	Biomedical Instrumentation Laboratory	0-0-3	2
55	BM 385	Medical Equipment Design Laboratory	0-0-3	2
56	BM 386	Experimental Biomechanics Laboratory	0-0-3	2
57	BM 387	Biomedical Signal Processing Laboratory – II	0-0-3	2
58	BM391	Special Topics in Biotechnology & Medical Engg. –I		3/4
59	BM392	Special Topics in Biotechnology & Medical Engg. –II		3/4
60	BM393	Special Laboratory in Biotechnology & Medical Engg. –I	0-0-3	2
61	BM394	Special Laboratory in Biotechnology & Medical Engg. –II	0-0-3	2
62	BM395	Engineering Product Development Project – I	0-0-6	4
63	BM396	Engineering Product Development Project – II	0-0-6	4
64	BM 401	Hospital Management	3-0-0	3
65	BM 402	Health Informatics	3-0-0	3
66	BM 403	Hospital Engineering and Information system	3-0-0	3
67	BM 405	Telemedicine	3-0-0	3
68	BM 411	Medical Embedded system	3-0-0	3
69	BM 413	Medical Imaging	3-0-0	3
70	BM 415	Electronic devices for Rehabilitation Engineering	3-0-0	3
71	BM 421	Tissue engineering	3-0-0	3
72	BM 422	Computer Application in Tissue Engineering	3-0-0	3
73	BM 423	Nanotechnology in Tissue Engineering	3-0-0	3
74	BM 424	Artificial Organs and Rehabilitation Engineering	3-0-0	3
75	BM 425	Biomaterials in Tissue Engineering	3-0-0	3
76	BM 427	BioComposites	3-0-0	3
77	BM 428	Nanotechnology in Biomedical Engineering	3-0-0	3
78	BM 429	Materials in medical science	3-0-0	3
79	BM 431	Physiological system modeling	3-0-0	3
80	BM 432	Biomicrofluidics	3-0-0	3
81	BM 433	Biotransport	3-0-0	3
82	BM 441	Protein Engineering	3-0-0	3

83	BM 442	Cancer Biology	3-0-0	3
84	BM 443	Introduction to Biotechnology	3-0-0	3
85	BM 444	Structural Biology	3-0-0	3
86	BM 452	Fermentation Technology	3-0-0	3
87	BM 463	Food Technology	3-0-0	3
88	BM 465	Biological Waste Treatment	3-0-0	3
89	BM 471	Bioprocess Design Laboratory	0-0-3	2
90	BM 472	Biomicrofluidics Laboratory	0-0-3	2
91	BM 473	Food Technology Laboratory	0-0-3	2
92	BM 481	Tissue Engineering Laboratory	0-0-3	2
93	BM 482	Computer aided Tissue Engineering Laboratory	0-0-3	2
94	BM 483	Computational Biomechanics Laboratory	0-0-3	2
95	BM 484	Structural Biology Laboratory	0-0-3	2
96	BM 491	Research Project–I	0-0-6	4
97	BM 492	Research Project–II	0-0-9	6
98	BM 493	Seminar and Technical Writing – I	0-0-3	2
99	BM 494	Seminar and Technical Writing – II	0-0-3	2
100	BM 495	Short term Industrial / Research Experience	0-0-3	2
101	BM 496	Comprehensive Viva Voce	0-0-0	2

BM 201 ANATOMY AND PHYSIOLOGY 3 credits [3-0-0]

Prerequisites: NIL

Introduction: Definition of human anatomy and physiology, anatomical terms and planes; Skeletal system: Classification of bones, joints and muscles, major muscles of limbs and their actions. Functional concept of the human body, bone and muscle physiology; Cardio Vascular System: Structure & function of Heart & blood vessels, Special functional tissue of heart, E. C. G., Cardiac cycle, Blood – composition, function, blood group, blood clotting. blood pressure- regulation & controlling factors; Respiratory system: Upper and lower respiratory tract, Structure and Function of respiratory membrane, Pulmonary circulation, Mechanics of breathing, Transport and control of gases, Lungs volume and capacities, Regulation of respiration, Pulmonary function tests; Nervous system & special senses: Brain and spinal cord, peripheral autonomic nervous system, nerve physiology, EEG, MEG & ECG; Eye & ear; Endocrine Glands: types, location, description and functions; Digestive system: Parts of digestive system, gastro intestinal tract and associated glands; Urinary system: Parts and function of urinary system; Male and female reproductive system and Lymphatic system: Spleen, glands and lymph nodes.

Essential Reading:

1. R. S Snell, ***Clinical Anatomy by Regions***, Lippincott Williams & Wilkins, 8th edition, 2007.
2. R. Drake, A. W. Vogl, Adam W. M. Mitchell, and R. Tibbitts, ***Gray's Atlas of Anatomy,*** Churchill Livingston, 1st edition, 2007.

Supplementary Reading:

1. K. Saladin, ***Anatomy & Physiology: The Unity of Form and Function***, McGraw-Hill College, 2006
2. E. N. Marieb, JonMallatt, P. B. W. Addison, ***Human Anatomy***, Wesley, 2007.
3. D. Shier, J. Butler, ***Ricki Lewis Hole's Human Anatomy & Physiology,*** McGraw-Hill College, 2006

BM 202 CLINICAL SCIENCE 4 credits [3-1-0]

Prerequisites: NIL

Pharmacokinetics, Pharmacodynamics, Drug dose, Enzyme kinetics, and Autonomic nervousystemdrugs, Hormonalmedicine, diovascular and renalmedicine, Chemotherapeutics and antibiotics, Neuropsychiatric drugs, Drug side effects, Cause of cancer, solid tumours of the body, Basics of Embryology, histopathology of normal and abnormal body tissues, Different type of blood cells and pathologies, Different types of microbes, Bacteria, Virus, fungal disorders, Protozoa and nematodes, Blood borne infections, Sign and symptoms, Gait analysis and orthopaedic problems, Detail anatomy of Eye and general ophthalmic disorders, Problems during anaesthesia, ventilation, Emergency treatment, Different types of surgical procedure, Pre-operative and Postoperative Care, Pregnancy and Labour, Common gynaecological and obstetrical problems, Common Skin and ENT disorders, Medical diagnostics, Advantage and disadvantages of different diagnostic Procedure.

Essential Reading:

1. A. S. Fauci, E. Braunwald, D. L. Kasper andS. L. Hauser, ***Harrison's Principles of Internal Medicine,*** McGraw-Hill Professional: 17th Edition, 2008
2. L. S. Bickley, ***Guide Physical Examination and History Taking,*** Lippincott Williams & Wilkins; 10thEdition2008

Supplementary Reading:

1. R. A Harvey, P. CChampe, R. Finkel and L. Cubeddu, ***Lippincott's Illustrated Reviews: Pharmacology,*** Lippincott Williams & Wilkins; 4th Edition 2008
2. E. Klatt and V. Kumar, ***Robbins and Cotran Review of Pathology,*** Saunders; 2nd Edition 2004

BM 203	CLINICAL BIOCHEMISTRY	3 credits [3-0-0]

Prerequisites: NIL

Living cell: Definition, structure and function, prokaryotic vs eukaryotic cells, sub cellular organelles, function of cell organelles, structure and function of cell membrane, transport of substances across cell membrane, cell to cell junctions and communications; Cellular Metabolism: Carbohydrate metabolism (Glycolysis, TCA cycle, Pentose Phosphate Pathway, Gluconeogenesis /Glycogen Metabolism, Malate and Lactate shunts, Regulation of Carbohydrate Metabolism), lipid metabolism (Fatty acid synthesis, Beta oxidation and regulation of FA metabolism), amino acids and protein metabolism, introduction to nucleic acid chemistry; Redox potential, Oxidative phosphorylation; Electrolytes: Acid base balance and biochemical measurement of acids –base and electrolyte status of the patients.

Essential Reading:

1. Robert Murray, Peter A Mayes, Victor W Rodwell, Daryl K Granner, ***Harper's Illustrated Biochemistry:*** McGraw Hill Companies, 27th edition, 2006.
2. Pamela C Champe, Richard A Harvey, Denise R Ferrier, ***Lippincott's Illustrated Reviews: Biochemistry:*** Lippincott Williams & Wilkins, 4 edition, 2007.

Supplementary Reading:

1. M. N. Chatterji and M. Schinde, ***Textbook of Medical Biochemistry***: CBS press, 4th edition 2004
2. Martin Holtzhauer, ***Basic Methods for the Biochemical Lab:*** Springer 1st edition, 2006.
3. Rao N Mallkarajuna, ***Medical biochemistry***, New age international Pvt Ltd, 2002

BM 205	CLINICAL MICROBIOLOGY	3 credits [3-0-0]

Prerequisites: NIL

Introduction to Microbiology; Prokaryotic cell structure and function; Microbialnutrition, Microbial growth, Control of Microorganisms by physical and chemical agents; Microbial genetics and Microbial Taxonomy; The Deinococci and Nonproteo bacteria G–ve; The proteo bateria; The low G+C grampositive bacteria; The high G+C grampositive bacteria; The Fungi and Slimemolds; Viruses; Medical Microbiology

Essential Reading:

1. Prescott/Harley/Klein's, ***Microbiology,*** McGraw-Hill Science / Engineering/Math, 7th Edition, 2007.

Supplementary Reading:

1. M. K. Cowan and K. P. Talaro, ***Microbiology: A Systems Approach,*** McGraw-Hill Science/Engineering/Math; 2nd edition, 2008.
2. M. J. Leboffe, M. Leboffe and B. E. Pierce, ***Photographic Atlas For The Microbiology Lab,*** Morton Publishing Company, 2nd Edition, 1999.

BM 232	BIOFLUID MECHANICS	4 credits [3-1-0]

Prerequisites: NIL

Properties of fluids: viscosity, density, specific volume, specific weight. Pressure and its measurement. Kinematics of fluid flow: types of fluid flow, continuity equation. Dynamics of fluid flow: Euler's equation, Bernoulli's equation. Circulatory biofluid mechanics: systemic and pulmonary circulations, circulation in the heart. Blood Rheology. Models of biofluid flows: Poiseuille's flow, pulsatile flow. Non-Newtonian fluids: power-law model, Herschel-Bulkley model, Casson model. Krogh model of oxygen diffusion from blood vessel to tissue. Dimensional analysis and modeling.

Essential Reading:

1. J. N. Mazumdar, ***Biofluid Mechanics***, World Scientific, 2004.
2. Frank M. White, ***Fluid Mechanics***, McGraw-Hill, 2010.

Supplementary Reading:

1. L. Waite and J. Fine***Applied Biofluid Mechanics,*** McGraw-Hill, 2007.
2. A. K. Jain, ***Fluid Mechanics***, Khanna Publishers.

BM 234	BIOTHERMODYNAMICS	3 credits [3-0-0]

Prerequisites: NIL

Energy transformation. First law of thermodynamics with examples from biochemistry. Second law of thermodynamics. Gibbs free energy and its application in biology: photosynthesis, glycolysis, osmosis, dialysis, membrane transport, ELISA, PCR. Reaction kinetics: rate constant and order of reaction, first-order and second-order reactions, Enzyme kinetics.

EssentialReading:

1. D. J. Haynie***, Biological thermodynamics***, Cambridge, 2008.

BM 242	IMMUNOLOGY	3 credits [3-0-0]

Prerequisites: NIL

Introduction, basic concepts in immunology, components of the immune system, principles of innate and adaptive immunity, Innate 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, Development and survival of lymphocytes, Lymphocytes in bone marrow and thymus, Positive and negatives election of lymphocytes, Survival and maturation of lymphocytes, The Adaptive Immune Response, T Cell-Mediated Immunity and cytotoxicity, Macrophage activation byarmed CD4TH1cells, Humoral Immune Response; Adaptive Immunity to Infection, Infectious agents and how they cause disease, The course of the adaptive response to infection, The mucosal immune system, Immunological memory; Failures of Host Defense Mechanisms, How do pathogens evade the immune system, Inherited immune deficiency 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. Janeway, Travers, Walport, and Shlomchik, ***Immuno biology, the immune system in health and disease,*** Garland Science Publishing, 6thEdition, 2005.

Supplementary Reading:

1. L. M. Sompayrac, ***How the Immune System Works (Blackwell's How It Works),*** Wiley-Blackwell; 3rd edition, 2008.

BM 244	CELL & MOLECULAR BIOLOGY	3 credits [3-0-0]

Prerequisites: NIL

Introduction: Properties of cells, cell membranes, subcellular organelles, Cytoskeleton; Cell Junctions: Types and structure of junctions (Tight Junctions, Adherens Junctions, Desmosomes); Cell communication: communication via diffusible molecules (surface receptors and intracellular receptors), Cellular Continuities (Contact-Mediated and ECM-Mediated), Role of ECM in Morphogenesis, Gap Junctions, Cell adhesion molecules: Modes of cell adhesion, classification and functions of CAMs; Signal Transduction via Surface Receptors: Classification and action of individual surface receptors (Ion Channel Linked Receptor, Enzyme Receptors, GuanylateCyclases, Receptor Tyrosine Kinases, Cytokine-Receptor Superfamily, G-Protein Coupled Receptor); cAMP Signaling from Receptor to Function; Dual Signalling Pathway: Inositol phosphates and protein kinase C, calcium & calmodulin; Cross-Talk, signal amplification & cascade mechanisms; Microtubules & Motor Proteins; Microfilaments, Myosins, and Microbes; Chemotaxis & the Inflammatory Response; Receptor-Mediated Endocytosis: The Events; Vesicle Trafficking: COPs, SNARES & Other Things; Protein Targeting; Cell Cycle: Stages, regulation of cell cycle specific genes, cellular aspects of cancer, Cellular, oncogenes and gene therapy.

Essential Reading:

1. Gerald Karp: ***Cell and Molecular Biology: Concepts and Experiments***; Wiley; 5 edition, 2007.

Supplementary Reading:

1. G. Nindl Waite, Lee R. Waite; ***Applied Cell and Molecular Biology for Engineers***; McGraw-Hill Professional; 1 edition, 2007.
2. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter; ***Molecular Biology of the Cell;*** Garland Science; 5 edition; 2004.

BM252	**BIOENERGETICS & METABOLISM**	**3 credits [3-0-0]**

Prerequisites: NIL

Free Energy Concept : Molecular basis of entropy, concept of free energy, standard free energy and measurement of free energy, significance in metabolism. Application of first and second law of thermodynamics to biological systems; Energy Conversions - Mitochondria: Sequence of electron carriers and sites of oxidativephosphorylation, ATP generation, and hemeandnon-hemeiron proteins. Thermodynamic considerations, oxidation - reduction electrodes, standard electrode potential, redox couples, phosphate group transfer potential; Chloroplast: Architecture, light harvesting complexes, bacteriorhodopsin, plastocyanin, carotenoids and other pigments. Hill reaction, photosystem I and II-location and mechanism of energy transfer. Calvin cycle, quantitative efficiency, photorespiration, C4 metabolism; Nitrogen Fixation: Biological fixation of nitrogen, symbiotic and nonsymbiotic nitrogen fixation. Nitrogenaseenzyme complex – azoferredoxin and molybdoferrodoxin. Physiological electron donors and mechanism of nitrogen reduction, assimilation of ammonia, nitrogen cycle.

Essential Reading:

1. V. Saks, ***Molecular System Bioenergetics: Energy for Life,*** Wiley-VCH; 1st Edition, 2007.

Supplementary Reading:

1. Nelson and W. H. Cox, ***Lehningers Principles of Biochemistry,*** Fourth Edition, 2004.
2. Greenspan and Baster, ***Basicand Clinical Endocrinology***.

BM 254	**BIOPROCESS CALCULATION**	**3 credits [3-0-0]**

Prerequisites: NIL

Introduction to Biochemical Engineering Calculations: Units and dimensions, mole concept, the chemical equations and stoichiometry, limiting and excess reactant, conversion and yield. Mass and energy balances in bioprocesses, flow sheet and process calculations, metabolic stoichiometry of growth and product formation, material balance and energy balance with recycle, by pass and purge streams. Solving material balance problems that do not involve chemical reactions, solving material balances problems involving chemical reactions, multiple subsystems, recycle, bypass, and purge calculations. Gases Vapors, Liquids and Solids: Ideal gas law calculations, real gas relationships, vapor pressure and liquids, saturation, partial saturation and humidity. Energy Balances: Concepts and units, calculation of enthalpy changes, application of the general energy balance without reactions occurring energy balances that account for chemical reaction, reversible processes and the mechanical energy balances, heats of solution and mixing, psychometric charts and their use. Microbial Stoichiometry

BM 256	**ENZYMOLOGY**	**3 credits [3-0-0]**

Prerequisites: NIL

The naming and classification of enzymes; structure and function of enzymes; specificity of enzyme action; monomeric and oligomeric enzymes; kinetics of single and multisubstrate enzymes catalyzed reactions; different types of enzyme inhibitors; sigmoidal and allosteric enzymes; chemical nature of enzyme catalysis; bindings of ligand to proteins; applications of enzymology.

Essential Reading:

1. T. Palmer (Ed), ***Enzymes: Biochemistry, Biotechnology, Clinical Chemistry***, Horwood Publishing Chinchester, 2001.
2. L. Stryer (Ed), ***Biochemistry***, W. H. Freeman & Co., New York, 1995.

BM 271	**ANATOMY AND PHYSIOLOGY LABORATORY**	**2 credits [0-0-3]**

Prerequisites: NIL

Identification of various organs and skeletal parts from charts and models-1, Morohometrics of human femur, skull and pelvis from CT Scan Images, Preparation of slices from tissue, fixation and examination under microscope, Preparation of blood film, staining and examination under microscope, TLC, DLC estimation of blood, Recording the ECG, EEG and EMG signal, Recording respiratory parameters through spirometry, Examination of eye with direct ophthalmoscope

BM 272	BIOFLUID MECHANICS LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Viscosity Measurement, Surface tension measurement, Verification of Bernoulli's theorem, Reynoldsapparatus, Pitottube, Flowmeasurement, Calculation of friction factor, Rheological testing of non-Newtonian fluid, Reciprocatingpump, Centrifugal pump

BM 273	CLINICAL BIOCHEMISTRY LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Study of plasma protein electrophoresis; Study of chromatography of aminoacids; Study of colorimetry. Study of spectrophotometer. Study of pHmeter. Quantitative estimation of glucose: Enzymatic method of glucose estimation in human blood sample. Quantitative estimation of serum urea and creatinine. Urine analysis for presence of: reducing sugars, proteins, ketonebodies, blood, bile salts and bile pigments.

BM 274	ANALYTICAL BIOTECHNOLOGY LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Determination of melting temperature of DNA, pH mediated equilibrium unfolding of protein, denaturant mediated equilibrium unfolding of protein; enzyme isolation and kinetics; monitoring protein-DNA interaction; monitoring protein aggregation through thioflavin T assay; calculation of binding parameters in proteins through quenching study; analysis of protein structure procured from protein data bank using swisspdb viewer; calculation of protein hydrophobicity, secondary structure, aggregation tendency through online softwares.

BM 275	CLINICAL MICROBIOLOGY LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Laboratory equipment and tools–The use of light microscope; Determination of cell number; size measurement of microbial cells. Preparation of media to culture micro organisms and ubiquity; Selective, differential and enriched media preparation; Observation of micro organisms: the wetmount technique Isolation and pure culture by streak plate technique; Differential stain: The Gramstain; The acid-faststain; The sporestain by Malachitegreen; The capsulestain by Indianink; The effect of antibiotics on bacteria: Determination of MIC of antibiotic against E. coli; Enumeration of heterotrophic bacteria from drinking watersource and tapwater: dilutions, calculations

BM 282	CLINICAL SCIENCE LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Urea, creatinine and electrolytes analysis of urine through ELISA Plate Reader, Identification of the various diagnostics and surgical tools in hospital scenario, Hb %, ESR, PCV, MCHC, MCH estimation, Interpretation of ECG from subjects, Interpretation and analysis of EEG Signal, Spectrophotometric analysis of various chemicals in blood serum, Isolation and Amplification of DNA for forensic examination

BM 311	MEDICAL SIGNAL & SIGNAL PROCESSING	4 credits [3-1-0]

Prerequisites: NIL

Introduction to biomedical signals, Sampling theorem, continuous and discrete LTI system, properties of LTI system; Introduction to Z Transform: The Z transform, properties of Z transform, inverse Z transform, transfer function in Z domain, location of poles and zeroes of Z- domain; Discrete Fourier Series and Transform: Discrete Fourier series, Discrete Fourier Transform(DFT), Fast Fourier Transform(FFT); Digital Filters Realizations: Characteristics of FIR filters, frequency response, design of FIR filters. Analog filter approximations-Butterworth and Chebychev. Design of IIR filters from analog filters: bilinear transformation method, step and impulse in variance techniques, spectral transformations. Introduction to joint time-frequency analysis.

Essential Reading:

1. Oppenheim and R. W Schafer, ***Digital Signal Processing***, Prentice Hall India, 2005
2. D. C. Reddy, ***Biomedical Signal Processing – Principles and Technique***, Tata McGraw-Hill., 2005

Supplementary Reading:

1. Antoniou, ***Digital Signal Processing***, McGraw Hill, 2005
2. Lefeachor, ***Digital Signal Processing***, Prentice Hall, 2002
3. J. G. Prokis and D. G. Manolakis, ***Digital Signal Processing: Principles, Algorithm and Applications***, PHI/Pearson Education, 1996

BM 312	BIOMEDICAL INSTRUMENTATION	4 credits [3-1-0]

Prerequisites: NIL

Transducers: Resistance type: Potentiometer, Strain gauge; inductive type: LVDT; Capacitive type: Differential pressure transmitter, Piezoelectric crystal; Sensing elements: Temperature sensing elements: RTD, Thermistor, Thermocouple, Semiconductor type (IC sensor); Pressure sensing elements: Manometers; Elastic elements: Bourdon tube, Bellows; Electrical type; Mcleod Gauge, Pirani Gauge; Flow sensing elements: Headmeters (Orifice, Venturi, Flow nozzle), Area meters (Rotameters), Electromagnetic flowmeter, Coriolisflowmeter. Measuring circuits: Deflection Bridge, Instrumentation amplifier; Signal conditioning: Switching devices: Relays (electromagnetic), Contactor, Transistor switches; OPAMP & Practical considerations: Inverting, Non-inverting, and differential configuration, Power amplification; Active and passive filters (low pass, high pass, band pass, notch); Isolation amplifiers; constant voltage and constant current sources for excitation, Wired signal transmission in industry (Voltage, 4-20 mA loop, Frequency); Signal Modulation; signal conversion: voltage-to-frequency, frequency-to-voltage, voltage-to-current, current-to-voltage; A/D and D/A converters.

Essential Reading:

1. Cromwell, Weibell & Pfeiffer, ***Biomedical Instrumentation & Measurement***, Prentice Hall, India, 2ndEdn. 2003
2. J. Webster, ***Bioinstrumentation***, Wiley & Sons. 2004.

Supplementary Reading:

1. J. Bronzino, ***Biomedical Engineering & Instrumentation***, PWS Engg. Boston. 3rd Edn.
2. J. Enderle, ***Bioinstrumentation***, Morgan & Claypool Publisher 2006.
3. R. S. Khandpur, ***Handbook of Bio-Medical Instrumentation***, Tata McGraw Hill, 2003

BM 313	BIOLOGICAL CONTROL SYSTEM	3 credits [3-0-0]

Prerequisites: NIL

Open and closed loop system. Mathematical models of physical systems. Transfer functions. Block diagram algebra, Signal flow graphs, Feedback characteristics of control systems. Control systems and components. DC and AC servomotors. Principles of stepper motors; Standard test signals. Time response of first order and second order systems. Design specifications of second systems. Proportional controller. PD controller, PID controller Necessary conditions for stability, stability criteria, Relative stability; Concept and construction of root locus, Root contours. Frequency response analysis, Correlation between time and frequency response, Bode plots, Stabilty in frequency domain. Nyquiststabilitycriterion; Examples of biological control system. Cardiovascular control system, respiratory control system, Bodytemperature regulation, Bloodglucose regulation; Pupilcontrolsystem, visual fixation system, Oculo-motorsystemskeletal muscle servo-mechanism, The semicircularcanal, Free swinginglimbs. Human operator tracking characteristics. Biological receptors.

Essential Reading:

1. O Katsuhika, ***Modem control engineering,*** 2nd edition, Prentice hall of India, 1992
2. I J Nagrath and M Gopal, ***Control Systems Engineering,*** 3rd edition, New Age publishers, 2002.

Supplementary Reading:

1. M C Khoo, Physiological Control ***Systems- Analysis, Simulation and Estimation,*** IEEE Press, 2000.
2. R P Van Wijk Van Brievingh and D P F moller (Eds), ***Biomedical Modeling and Simulation on a PC –A workbench for physiology and biomedical engineering,*** springer verlag, 1993.

BM 314 BIOMEDICAL IMAGE PROCESSING 4 credits [3-1-0]

Prerequisites: NIL

Digital image fundamentals: Image digitization, sampling & quantization, neighbor of pixels, connectivity, relations, equivalence & transitive closure, distance measures, arithmetic/logic operations, Different types of transform-discrete, fast Fourier, 2-D Fourier & inverse Fourier Image enhancement fundamentals: Spatial & frequency domain methods, contrast enhancement, histogram processing, image smoothing, image averaging, masking, image sharpening, removing of blur caused by uniform linear motion, enhancement in the frequency domain; Image restoration fundamentals: Degradation model, discrete formulation, algebraic approach to restoration–unconstrained & constrained; Image compression and segmentation fundamentals: Fidelity criteria, image compression models, lossy and lossless compression technique. Image segmentation: point detection, line detection, edge detection, edge linking and boundary detection; Algorithms used in medical image processing: Brief of reconstruction techniques – algebraic, simultaneous iterative and simultaneous algebraic. Reconstruction algorithm for parallel projections, fan beam projection and back projection. Introduction to various approaches of pattern recognition.

Essential Reading:

1. P. Suetens, ***Fundamentals of image processing***, Cambridge University Press, 2002.
2. Gonzalez and Woods, ***Digital image processing***, 2nd ed., Pearson, 2007

Supplementary Reading:

1. R. C. Gonzalez, R. E. Woods, S. L. Eddins, ***Digital Image Processing Using MATLAB(R), Course Technology,*** 1 edition, 2004
2. A. K Jain, ***Fundamentals of image processing***, prentice hall, Eagle cliffs, New Jersey, 1989
3. Chanda & Majumdar, ***Digital image processing and analysis***, PHI, 2003

BM 315 LASER & FIBER OPTICS IN MEDICINE 3 credits [3-0-0]

Prerequisites: NIL

Laser characteristics: Single frequency operation, coherence of laser, spatial distribution, intensity of laser emission, polarization of laser emission, measurement of pulsed laser energy. Principles of laser applications in medicine and biology; Laser in biology: Optical properties of tissue, Pathology of laser reaction in skin, thermal effects, laser irradiation, Non thermal reactions of laser energy in tissue, effect of adjuvant; Lasers in surgery: Surgical instrumentation of CO2, Ruby, Nd-YAG, He-Ne, Argonion, Q-switched operations, continuous wave, Quasi–continuous, surgical applications of the selasers; Laser applications: Lasers in dermatology, lasers in ophthalmology, laser photocoagulations, laser in dentistry, Laser flow cytometry, Laser transillumination & diaphanography- Speckle intereferometry, holography -Application Safety with biomedical Lasers; Fiberoptics in diagnosis: Transmission of signals, light and construction details of optical fiber, application of fiberoptics in medicalfield.

Essential Reading:

1. L. Goldman, ***The Biomedical laser Technology and Clinical Applications***, Springer, 1981
2. Hans-Peter Berlien, Gerhard J. Müller, H. Breuer, and N. Krasner, ***Applied Laser Medicine***, Springer; 1 edition, 2004

Supplementary Reading:

1. Francis T. S. Yu and Shizhuo Yin, ***Fiber Optic Sensors,*** CRC; 1 edition 2002
2. Nandini K. Jog, ***Electronics in medicine and biomedical instrumentation***, Prentice Hall of India

BM 316 BIOSENSORS AND BIOTRANSDUCERS 3 credits [3-0-0]

Prerequisites: NIL

Classification of transducers, selecting of transducers, circuit based on transduction Temperature transducers, Displacement transducers, Pressure transducer, photoelectric transducers, Flow transducers, piezoelectric transducers and their applications; Sensors/receptors in the human body, basic organization of nervous system-neural mechanism and circuit processing, Chemoreceptor, sensor models in the time and frequency domains; Biochemical Transducers-Electrode theory: electrode-tissue interface, metal-electrolyte interface, electrode-skin interface, electrode impedance, electrical conductivity of electrode jellies and creams; Biopotential electrodes, Reference electrodes, Recording electrodes for ECG, EEG and EMG. Transducers for the measurement of ions and dissolved gases, pH electrode, specific ion electrodes; Biosensors-Ion exchange membrane electrodes. Types, basic components and medical applications of biosensors, Basic principles of MOSFET biosensors & BIOMEMS; Optical sensor-photodetectors, optical fiber sensors, and indicator mediated transducers, general principles of optical sensing, optical fiber temperature sensors. Pulse sensor: photoelectric pulse transducer, strain gauge pulse transducer.

Essential Reading:

1. ***Handbook of Biosensors and Electronic Noses: Medicine, Food and the Environment,*** CRC-Press; 1 edition; 1996
2. T. Togawa, T. Tamura, P. Ake Oberg, ***Biomedical Transducers and Instruments***, CRC Press, 1997

Supplementary Reading:

1. ***Biosensors,*** Oxford University Press, USA; 2 edition, 2004
2. D. L. Wise, ***Biosensors: Theory and Applications***, CRC Press, 1993, 2001

BM 317	BIOMEDICAL ENGINEERING	3 credits [3-0-0]

Prerequisites: NIL

History of Biomedical Engineering; Moral & Ethics; Anatomy & Physiology; Rehabilitation Engineering; Biomaterials; Artificial organs; Tissue Engineering; Biomedical Instrumentation; Biomedical Sensors; Biosignal Processing; Bioelectric Phenomena; Biomedical Imaging; Patient Safety in Hospitals; Biomedical waste disposal.

Essential Reading:

1. J. D. Enderle, Susan M. Blanchard, Joseph D; Bronzino***, Introduction to Biomedical Engineering-*** Academic Press, 2005
2. J. D. Bronzino, ***Biomedical engineering fundamentals***; CRC Press, 2006

Supplementary Reading:

1. A. B. Ritter, Stanley Reisman, Bozena B. Michniak***, Biomedical Engineering Principles***, CRCPress, 2005
2. Silver Frederick H, ***Biomaterials, Medical Devices and Tissue Engineering***, Chapman & Hall, London- 1994
3. Leslie, Cromwell, Fred J. Weibell, Erich A. Pfeiffer; ***Biomedical Instrumentation and Measurements***; 2nd ed. Pearson Education-2004

BM 318	MEDICAL INSTRUMENTATION	3 credits [3-0-0]

Prerequisites: NIL

Human body, Biomedical Instrumentation and Measurement, Basic Principles of Measurement, Electrodes, Sensors, and Transducers, Bioamplifiers, Electrocardiographs, Physiological Pressure and Other Cardiovascular Measurements and Devices, Measurement of Respiratory Parameters, Respiratory Therapy Equipment, Measurement of Brain Function, Intensive and Coronary Care Units, Operating Rooms, Medical Laboratory Instrumentation, Medical Ultrasonography, Electrosurgery Generators, Battery-Operated Medical Equipments, Electro-Optics, Radiology and Nuclear medicine Equipment, Electromagnetic Interference, Quality Assurance, Quality Improvement, Medical Equipment Maintenance.

Essential readings:

1. John G Webster, ***Medical Instrumentation: Application and Design***, ISBN: 8126511060, ISBN-13: 9788126511068, 978-8126511068, Publisher: Wiley India Pvt Ltd, Edition: 3rd Edition (2007).
2. John G. Webster, Clark John W. Jr., Michael R. Neuman, ***Medical Instrumentation: Application and Design***, ISBN: 0471676004, ISBN-13: 9780471676003, 978-0471676003, Publisher: John Wiley & Sons, Edition: 4th Edition (2009).

Suggested Readings:

1. Shakti Chatterjee, Aubert Miller, ***Biomedical Instrumentation Systems***, Publisher: Delmar Cengage Learning; 1 edition, ISBN-10: 141801866X, ISBN-13: 978-1418018665.
2. Barbara Christe, ***Introduction to Biomedical Instrumentation: The Technology of Patient Care,*** Publisher: Cambridge University Press; 1 edition, ISBN-10: 0521515122, ISBN-13: 978-0521515122

BM 321	BIOMATERIALS	4 credits [3-1-0]

Prerequisites: NIL

Introduction, biomaterials in medicine; Metallic implant materials: different types, Host tissue reaction with biometal, corrosion behavior and the importance of passive films for tissue adhesion. Hard tissue & Soft tissue replacement; Polymeric implant materials: Types and classification, Mechanical, Surface, Electrochemical & Physiochemical properties of biopolymers. Biodegradable polymers for medical application. Synthetic polymeric membranes and their biological applications; Ceramic implant materials: Types of bioceramics, I mportance of wear resistance and low fracture toughness. Host tissue reactions: importance of interfacial tissue reaction; Composite implant materials: Mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement. Polymers filled with osteogenic fillers. Host tissue reactions; Testing of Biomaterials: biocompatibility, blood compatibility and tissue compatibility, Toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests, Invitro and Invivo testing; Sterilisation of implants and devices: ETO, gamma radiation, autoclaving. Effects of sterilization.

Essential Reading:

1. S. V. Bhat, ***Biomaterials***, Springer, 2002.
2. JB ParkandJ. D. Boonzino, ***Biomaterials: Principles and Application***, CRC Press, 2002

SupplementaryReading:

1. J. Black, ***Biological Performanceofmaterials***, Taylor & Francis, 2006
2. C. P. SharmaandM. Szycher, ***Blood compatible materials and devices***, TechnomicPublishingCo. Ltd., 1991.
3. J. B. ParkandR. S. Lakes, ***An Introductionto Biomaterials***, Springer, 2007
4. B. D. Ratner, F. J. Schoen, A. S. Hoffman, J. E. Lemons, ***BiomaterialsScience: An introductionto Materialsin medicine***, AcademicPress, 2004.

BM 322	BIOPOLYMERS	3 credits [3-0-0]

Prerequisites: NIL

Introductions to biopolymers, properties of biopolymers, structure-properties relationship, applications. Polysaccharides: alginates, dextrans, chitosan, hyaluronic acids. Bacterial polyesters: poly(hydroxyl alkanoates), poly(hydroxybutyrates). Proteinas: collagen, fibrin, gelatin, albumin. Artificical biopolymers: aliphatic polyesters derived from lactic and glycolic acids, aliphatic polyesters derived from malic acid, polyamides derived from citric acid and lysine, primary amine-containing polyesters derived froms erine.

Essential Reading:

1. B. D. Ratner, A. S. Hoffman, F. J. Schoen, J. E. Lemons, ***BiomaterialsScience,*** AcademicPress; Edition 1, 1996.
2. J. Y. Wong, J. D. Bronzino, ***Biomaterials,*** CRC Press, Edition 2007

SupplementaryReading:

1. SweeHinTeoh, ***Engineering Materials for Biomedical Applications,*** World Scientific Edition1, 2004.
2. J. B. Park, J. D. Bronzino, J. D. Bronzino, ParkB. Park, ***Biomaterials: Principles and Applications,*** Taylor & Francis, Edition1, 2002.

BM 324	SURFACE ENGINEERING OF BIOMATERIALS	3 credits [3-0-0]

Prerequisites: NIL

Surface dependent engineering properties, common surface initiated engineering failures; mechanism of surface degradation of material used in the body and outside the body in natural environment in service condition, Importance and necessity of surface engineering; Classification and scope of surface engineering in metals, ceramics, polymers and composites, tailoring of surfaces of advanced materials; Surface protection; surface modification techniques: classification, principles, methods, and technology; conventional surface engineering methods: electrochemistry and electro-deposition; Scope and application of conventional surface engineering techniques in engineering materials; advantages and limitations of conventional processes; Recent trend in surface engineering: physical/chemical vapour deposition; plasma spray coating; plasma assisted ion implantation; surface modification by directed energy beams like ion, electron and laser beams; Characterization and testing/evaluation of surface- properties; structure-property correlation. Economics and energy considerations, designing of surface engineering processes; Surface engineering of medical instruments and implants.

Essential Reading:

1. L. Hao and J. Lawrence, ***Laser surface treatment of Bio-implant materials,*** John-Wiley and Sons publishers, 2006.
2. K. G. Budinsky, ***Surface engineering for wear resistance***, VIed, PrenticeHall, NewYork 1998.

SupplementaryReading:

1. J. E. Ellingsen, S. PetterLyngstadaas, ***Bio-Implant Interface: Improving Biomaterials and Tissue Reactions,*** CRC Press, 2003:
2. G. Rakhorst, R. Ploeg, ***Biomaterials InModern Medicine: The Groningen Perspective***, World Scientific PublishingCompany; 1stedition2008.

BM 331	BIOHEAT AND MASS TRANSFER	4 credits [3-1-0]

Prerequisites: NIL

Fundamentals of heat and mass transfer in biological systems - Thermoregulation, Metabolism, Thermal comfort. Temperature in living systems –hyperthermia and hypothermia. Modes of Heat Transfer – Conduction, Convection, and Radiation. Basic law of heat conduction – Fourier's law; thermal conductivity of biological materials, temperature dependence of thermal conductivity, steady state heat conduction through a layered surface with different thermo-physical properties (e.g. skin). Effect of metabolism on heat transfer. Transient (unsteady state) heat conduction. Heat transfer with phase change – freezing and thawing. The bio-heat transfer equation for mammalian tissue. Convection heat transfer and the concept of heat transfer coefficient, individual and overall heat transfer coefficient, critical/ optimum insulation thickness, heat transfer through extended surfaces. Radiation exchange between surfaces, Mass Transfer: Equilibrium, Mass conservation, and kinetics, Modes of Mass Transfer: Diffusion, Dispersion, and Advection. Governing equations and boundary conditions of mass transfer, Steady and unsteady diffusion mass transfer (e.g. drug delivery), Convection mass transfer, Local and overall mass transfer coefficient, heat and mass transfer analogy. Flow in porous media.

Essential Reading:

1. Ashim K. Datta, Biological and ***Bioenvironmental Heat and Mass Transfer***: Marcel Dekker, Inc., 2002.
2. Frank P. Incropera and David P. DeWitt, ***Fundamentals of Heat and Mass Transfer***: John Wiley & Sons; 5th edition 2006.

BM 332	BIOMECHANICS	3 credits [3-0-0]

Prerequisites: NIL

Review of principles of mechanics, vector mechanics - resultant forces of coplanar and non- coplanar and concurrent and non-concurrent forces, parallel forces, equilibrium of coplanar forces, Newton's laws of motion, work and energy, moment of inertia; Analysis of rigid bodies in equilibrium, free body diagrams, system analysis in equilibrium, types of support or joint, Analysis of joints in various postures, Basic assumptions and limitations, biomechanical analysis of elbow, shoulder, spinal column, hip knee and ankle; Forces involve in blood flow, general Bernoulli's equation, wind kessel model, stress in the ventricular wall, pressure volume loop. Hagen-poiseuillelaw – derivation and applications, steady laminar flow in elastic tube, wave propagation in blood, reflection and transmission of waves at arterial junctions, blood flow in veins, microcirculation; Mechanism of air flow, respiratory cycle, lung ventilation model, methods of determining pressure, flow rate and volume spirometry, respiratory plethysmography, diagnostic significance of the lung-ventilation model, static and dynamic respiratory mechanics tests; Design of orthopedic implant, specifications for aprosthetic joint, biocompatibility, requirement of a biomaterial, characteristics of different types of biomaterials, manufacturing process of implants, fixation of implants.

Essential Reading:

1. YCFung, ***Biomechanics: MechanicalPropertiesofLivingTissues***, Springer, 2ndEdition, 1993.
2. N. OzkayaandM. Nordin, ***Fundamentals of Biomechanics-Equilibrium, Motion and Deformation***, Springer-verlag, 2nd Edition1999

SupplementaryReading:

1. J. GWebster, ***Medical Instrumentation –Application and design***, JohnWileyand sons Inc. 3rded. 2003.
2. D. Dowson and V. Wright, ***An introduction to Biomechanics of joints and joint replacements***, Mechanical Engineering Publications, 1980
3. Y. C. Fung, ***Biodynamics-circulation***, Springer-Verlag, 1994.

BM 341	GENETIC ENGINEERING	4 credits [3-1-0]

Prerequisites: NIL

Introduction: Genes, Chromatin, Chromosomes and Genome; Cell and tissue culture techniques; DNA technology: Scope and Gene cloning - concept and basic steps; application of bacteria and viruses in genetic engineering; Molecular biology of E. coli and bacteriophages in the context of their use in genetic engineering; Gene cloning: Restriction endonucleases, ligases and other enzymes useful in gene cloning, PCR technology for gene/DNA detection, cDNA, usages of plasm id and phagesas vectors; Model vectors for eukaryotes-Viruses, Gene libraries; Use of marker genes; Medicine related applications i.e. commercial synthesisof hormones and vaccines. Microbial applications i.e.large scale preparation of organic chemicals, bio-mining, microorganisms as feed of livestock; Biotechnology and environment i.e. pollution control, wastedisposal, biogas; Monoclonal antibodies and their applications.

Essential Reading:

1. Desmond S. T. Nicholl; ***AnIntroductiontoGenetic Engineering,*** Cambridge UniversityPress, 3rd Edition, 2008.

SupplementaryReading:

1. M. Gen, R. Cheng, ***GeneticAlgorithmsandEngineeringDesign,*** Wiley-Interscience, 1st Edition, 1997.
2. J. A. Nolta, ***GeneticEngineering of MesenchymalStemCells,*** Springer, 1th edition, 2006.

BM 342 APPLIED CELL BIOLOGY 3 credits [3-0-0]

Prerequisites: Biochemistry, Cell and Molecular Biology

Structural intricacy & Chemical composition of cells, Structure, diversity and function of receptor and ion channels, Intercellular communication, From cells to tissue, Cell Adhesion, Cell Migration, Cell Proliferation, Cell Differentiation, Cell Death, Endocytosis, Mechano-transduction, Stem cell, Cell culture and characterization of cells, Concepts of Immuno-compatibility, Interface of cell biology with pharmaceutical technology / Bio-nano technology/ Biomedical Engineering / Tissue engineering / Regenerative Medicine.

Essential Reading

1. B. Alberts, D. Bray, K. Hopkin, A. Jhonson***, Essential of cell biology***, 3rd edition, Garland Science
2. H. Lodish, A. Berk, C. A. Kaiser, M. Kreiger, ***Molecular Cell Biology***; 6th edition, W. H. Freeman

Supplementary Reading

1. R. I Freshney, ***Culture of Animal cell: A manual of basic techniques and specialized application***, Black well 6th edition.
2. J. Hancock, ***Cell Signaling***, Academic Press

BM343 BIOINFORMATICS 3 credits [3-0-0]

Prerequisites: NIL

Scope of Bioinformatics, Elementary commands and protocols, ftp, telnet, http; Primer on information theory; Introduction to Homology (with special mention to Charles Darwin, Sir Richard Owen, Willie Henning and Alfred Russel Wallace); DNA mapping and sequencing; Map alignment; Large scale sequencing methods (Shotgun and Sanger method); Heuristic Alignment algorithms; Global sequence alignments– Neddleman– Wunsch Algorithm Smith-Waterman Algorithm-Local sequence alignments (Amino acid substitution Matrices (PAM, BLOSUM); Introduction to Biological databases; Organization and management of databases; Searching and retrieval of information from the World Wide Web; Structure databases– PDB (ProteinData Bank), Molecular Modeling Databases (MMDB); Primary Databases (NCBL, EMBL, DDBJ); Introduction to Secondary Databases Organization and management of databases (Swissprot, PIR, KEGG); Introduction to BioChemical databases-organization and Management of databases(KEGG, EXGESCY, BRENDA, WIT); Multiple sequence alignment and phylogenetic analysis.

Essential Reading:

1. H. H. Rashidi and L. K. Buehler, ***Bioinformatics Basics Applications in Biological Science and Medicine***, CAC Press, 2000.
2. D. Gusfiled, ***Algorithmson Strings Trees and Sequences,*** CambridgeUniversityPress, 1997.

SupplementaryReading:

1. P. Baldi and S. Brunak, ***Bioinformatics: A Machine Learning Approach***, MIT Press, 1988.
2. D. Mount, ***Bioinformatics,*** CSH Publications, 2000.
3. ***Genomics and Proteomics-Functional and Computational aspects***. Springer Publications, Editior-Sandor Suhai.

BM 345 ANIMAL TISSUE CULTURE 3 credits [3-0-0]

Prerequisites: NIL

Basics of Cell and Tissue Culture: Laboratory requirements for tissue culture, substrates for cultures, culture media for animal cell cultures, culture procedures and principles, freeze storing of cells and transport of cultures. Characteristics of Cells in Culture: Contact inhibition, anchorage independence/dependence, cell-cell communication, cell senescence. Cell Culture Lines: Definition, development and maintenance, cloning of celllines, cell synchronization viral sensitivity of cell lines, cell line preservation and characterization, stem cell lines. General Tissue Culture Techniques: Types of tissue cultures, methods of disaggregating primary cultures, primary tissue explantation technique. Organ Culture: Methods, behavior of organ explants and utility of organ culture, whole embryo culture. Methods in Cell Culture: Micro carrier cultures, cell immobilization, animal cell bioreactor, large scale cell cultures for biotechnology, somatic cell fusion, flow cytometry, transfection. Applications of Animal Cell Culture: Use in gene therapy, cloning from short-term cultured cells, cloning from long-term cultured cells, Cloning for production of transgenic animals, cloning for conservation.

Essential Reading:

1. RIFreshney, ***Culture of Animal Cells: Amanual of basictechnique***, 4thEdition, WIELY- LISS, 2005.

Supplementary Reading:

1. JR. W. Masters, ***Animal Cell Culture: A Practical Approach,*** Oxford University Press, 3rd edition, 2000.

BM 352 BIOCHEMICAL ENGINEERING 4 credits [3-1-0]

Prerequisites: NIL

Concept of ideal reactors based on flowc haracteristics, design of Ideal reactors using material and energy balance equations. Single reactors, with ideal flow condition, comparison of volumes of plugflow reactor and chemostat. Multiple reactors-methods to show how total volume is affected in multiple reactors. Searching for mechanism – Arrhenius equation – Batch reactor analysis for kinetics (synchronous growth and its application in product production). Growth Kinetics: Batch growth quantifying cell concentration, growth profiles and kinetics in batch culture, fedbatch growth, continuous growth and their grow the kinetic quantification, chemo stat growth, semi-continuous / exponential feeding strategy. Maximizing the yield of intermediate production series reactions Design principles–Nonisothermal reactions and pressure effects; Non-ideal flow in bioreactors-reasons for non-ideality, concept of RTD studies, characterization of non-ideality using RTD studies, various distribution functions, conversions using tracer studies. Diagnosing the ills of nonideal bioreactors, various models of nonideal flow. Design and analysis of bioreactors-stability and analysis of bioreactors, biomass production and effect of dilution rate. Design and operation of various bioreactors, viz CSTF, fed batch systems, air- lift bioreactors, fluidizedbed bioreactors. Scale up of bioreactors. Criteria for selection of bioreactors.

Essential Reading:

1. D. G. Rao, ***Introduction toBiochemical Engineering***, Tata McHill, 2005.
2. J. E. Baileyand D. F. Ollis, ***Biochemical Engineering Fundamentals***, 2nd edition, McGraw- Hill, 1986.

SupplementaryReading:

1. J. E. BaileyandD. F. Ollis, ***BiochemicalEngineeringFundamentals,*** McGrawHillHigherEducation; 2ndedition, 1986.

BM 353 PHARMACEUTICAL TECHNOLOGY 3 credits [3-0-0]

Prerequisites: NIL

Introduction, Pharmacokinetics vs pharmacodynamics, Bioavailability, Conventional pharmaceutical dosages forms; tablet, capsule, ointment, parenteral products, opthalmic products, aerosols, emulsions. Controlled drug delivery systems; microparticles, nanoparticles, liposome, neosome, hydrogel, transdermal patch, mucoadhesivebuccal and sublingual preparation. Targeted drug delivery system, Environment sensitive drug delivery system and Remote controlled drug delivery system. Overview of Biopharmaceuticals, Recombinant growth factor and enzyme, therapeutic antibodies, vaccines, adjuvants, cell therapy.

Essential Reading:

1. H. A. Lieberman, L. Lachman and J. B. Schwartz, ***Pharmaceutical Dosage forms*** (Vol 1, 2 and 3), Second edition, Informa Health Care.
2. Mathiowitz Edith, ***Encyclopedia of Controlled Drug Delivery***, John Wiley & Sons

Supplementary Reading:

1. Binghe Wang, Teruna J. Siahaan, Richard A. Soltero, ***Drug Delivery: Principles and Applications***, John Wiley & Sons.
2. T. Scheper, ***Gene Therapy and Gene Delivery Systems*** (Advances in Biochemical Engineering / Biotechnology), Springer.
3. D. J. A. Crommelin, R. D. Sindler, B. Meibohm, ***Pharmaceutical Biotechnology; Fundamental and Application***; 3rd edition, Informa Health Care

BM 354 BIOSEPARATION 4 credits [3-1-0]

Prerequisites: NIL

Basic concepts of Bio-separation Process, Separation characteristics of proteins and enzymes– size, stability, properties; purification methodologies Characteristics of bio-products; overview of reaction processes involved in separation, numerical examples illustrating the process; Filtration and Centrifugation. Filtration at constant pressure and at constant rate; empirical equations for batch and continuous filtration, centrifugal and cross-flow filtration, Centrifugation: basic principles, design characteristics; ultracentrifuges: principles and applications; Techniques Involved in Separation Processes; Solvent extraction of bio-processes, aqueous two-phase extraction, adsorption-desorption process; Salt precipitation; Chromatographic separation based on size, charge hydrophobic interactions and metal ion affinity. Affinity chromatography, inhibitors: their preparation and uses, method of linkages, Electrophoresis SDS-PAGE (Polyacrylamide Gel), horizontal and vertical type, methods, case studies; Membrane based separation processes. Micro-filtration, Reverse osmosis, Ultra filtration and affinity ultra filtration, concentration polarization, rejection, flux expression, membrane modules, dead-ended and cross-flow mode, material balances and numerical problems, biological applications.

Essential Reading:

1. P. A. Belter, E. L. CusslerandWei-ShouHu, ***Bioseparations: Downstream Processing for Biotechnology,*** Wiley-Interscience, 1st edition, 1988.
2. S. Ahuja, ***Handbook of Bioseparations***, Volume2(Separation Science and Technology), Academic Press, ISBN-13: 978-0120455409, 1st edition, May2000.

SupplementaryReading:

1. Bailey & Olis, ***Biochemical Engg. Fundamentals***, McGraw-Hill, 1990.
2. S. N. Mukhopadhyay, ***Process Biotechnology Fundamentals***, Viva BooksPvt. Ltd. 2001

BM 356	BIOINSTRUMENTATION AND PROCESS CONTROL	4 credits [3-1-0]

Prerequisites: NIL

Introduction and review of process control; Basic electrical components; Basic electronics circuits; Industrial Instrumentationà Pressure measurement, level measurement, flow measurement, temperature & heat measurement, humidity measurement, density measurement, viscosity measurement, pH measurement, position & motion sensors, force, torque & load sensors, smoke & chemical sensors, sound & light sensors; Actuators & control; Signal conditioning; Signal transmission; Process controlàControl modes, Implementation of control loops, Digital controllers; Documentation and symbols.

Essential readings:

1. Curtis Johnson, ***Process Control Instrumentation Technology***, ISBN: 8120330293, Publishing Date: 2009, Publisher: Phi Learning, Edition: 8th Edition.
2. William C. Dunn, ***Fundamentals of Industrial Instrumentation And Process Control***, ISBN: 0070677492, Publishing Date: 2009, Publisher: Tata Mcgraw Hill Education Private Limited, Edition: 1st Edition.

BM358	BIOREACTOR ANALYSIS & DESIGN	3 credits [3-0-0]

Prerequisites: NIL

Types of reactors- batch, plug flow reactor (PFR), continuous stirred rank reactors (CSTR), fluidized bed reactor, bubble column, air life fermenter, etc; concept of ideal and non-ideal reactor; residence time distribution; Models of non-ideal reactors? plugflow with axial dispersion, tanks-n-series model; Chemostat model with cell growth kinetics; Plugflow reactor for microbial processes; optimization ofreactor systems; Multiphase bioreactors? Packed bed with immobilized enzymes or microbialcells; three? Phase fluidized bed trickling bed reactor; Design and analysis of the above reactor systems; Gas liquid reactors; Unconventional bioreactors like Hollow fiberreactor, membrane reactor, perfusion reactor for animal and plant cell culture.

Essential Reading:

1. J. A. Asenjo, ***Bioreactor System Design (Biotechnology and Bioprocessing Series),*** CRC, 1st Edition, ISBN-13: 978-0824790028, 1994.

SupplementaryReading:

1. J. M. S. Cabral, M. Mota, and J. Tramper, ***Multiphase Bioreactor Design***, CRC, ISBN-13: 978-0415272094, 2001.

BM361	AGRICULTURAL BIOTECHNOLOGY	3 credits [3-0-0]

Prerequisites: NIL

Molecular Markers: Comparison of different types of markers: -RFLP, RAPD, AFLP, AP-PCR, STS, EST, SNP, DNA Microarray; Construction of Molecular Maps Genome Sequencing in Plants and Functional Genomics. TransplastomicPlants: Engineering and Transformation of Chloroplast Genome. Genetic Improvement of Plants using different Invitroculture Techniques. Development of crops adaptable to environmental stresses, diseases and pests. Transgenic plants: Molecular Farming: Plants As factories for biopharmaceuticals, Transgenic value added speciality crops, Use of antisense RNA and other technologies. Biofertilizers, Biopesticides, BioinsecticidesSoil Reclamation: Phytoremediation.

Essential Reading:

1. M J Chrispeels, ***Plants, Genes and Crop Biotechnology,*** Jones and Bartlett Publishers, Inc., 2nd Sub edition, 2002.

SupplementaryReading:

1. B Shmaefsky, ***Biotechnology on the Farm and in the Factory: Agricultural and Industrial Applications (Biotechnology in the 21st Century),*** Chelsea House Publications, 2005.

BM362	PLANT TISSUE CULTURE	3 credits [3-0-0]

Prerequisites: NIL

Introduction to cell and tissue culture; Tissue culture media(composition, preparation); Initiation and maintenance of callus and cell suspension culture, organogenesis; Protoplast isolation culture and fusion; Production of haploids, Somaclonalvariations, Germplasm conservation (Cryopreservation); Production of secondary metabolites from plant cell cultures; Processes for enhancing the production of secondary metabolites. Technology of plant cell culture for production of chemicals; Bioreactors systems and models for mass cultivation of plant cells; Agrobacterium mediated gene transfer; Agrobacterium based vectors, viral vectors and their application; Direct gene transfer methods; chemical methods, electroporation, microinjection, particle bombardment. Herbicide resistance, Insect resistance, Disease resistance, virus resistance, Abiotic stress tolerance: Drought, temperature, salt; Application of plant biotechnology for the production of quality oil, Industrial enzymes, Antigens(edible vaccine)and plant antibodies; Metabolic engineering for plant secondary metabolites.

Essential Reading:

1. R. Smith, ***Plant Tissue Culture: Techniques and Experiments***, 2nded., Academic Press, 2000.

Supplementary Reading:

1. M. J. Crispeels and D. E. Sadava, ***Plants, Genes and Crop Biotechnology***, Jones and Bartlett Publishers (2nd Edition), 2003.

BM 370	BIOINFORMATICS LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

An introduction to the computing platforms on which the course is taught: Remote computing, text editing, basics of the UNIX operating system, and the X environment. Molecular databases and how they are organized and accessed: Wisconsin Package and its graphical user interface (GUI) SeqLab and the on-site GCG sequence databases will be reviewed. Access methods like WWW, NCBI's Entrez. Unknown DNA -- rational probe design and analysis -- the "guessmer": Designing and analyzing oligonucleotide primers for discovering genes in organisms. DNA fragment contiguous assembly (GCG's SeqMerge) and restriction enzyme mapping. Database similarity searching and the dynamic programming algorithm: Methods and algorithms, their limitations, and the significance of their findings. Gene finding strategies: Searching by signal versus searching by content, i.e.transcriptional/translational regulatory sites and exon/intron splice sites, versus 'nonrandomness, ' codon usage; and homology inference. Multiple sequence alignment, expectation maximization, profiles, and Markov models. Molecular evolutionary phylogenetic inference: PAUP* (Phylogenetic Analysis Using Parsimony [and Other Methods], PHYLIP (PHYLogeny Inference Package), and other tools. 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. Molecular modeling and visualization.

BM 371	CELL AND MOLECULAR ENGINEERING LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Introduction to relevant equipment; Learning mammalian cell culture, subculture and storage (human fibroblasts); Isolation and purification of nucleic acids (human fibroblasts)

RNA

DNA ((lysis, extraction, ethanol precipitation and resuspension of DNA)

Gene amplification from isolated DNA and RNA

End point PCR

Real time PCR

Electrophoresis of DNA: Gel electrophoresis; Plasmid: Plasmid preparation; transformation; restriction digestions (pGLO) and gel electrophoresis of digest; Transfection (E. coli): Transfection of antibiotic resistance gene by heat shock and electroporation followed by validation; Induction of gene expression: Grow pGLO bacteria, shift to different concentrations of arabinose, collect samples at various intervals, quantitate fluorescence and optical density; Conjugation: Mix donor and recipient; interrupt mating at specific times; plate, count colonies and analyze data; Demonstration of Hybridoma technology

BM 372	BIOSEPARATION LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Separation of proteins (>60kDa) from cell debris using centrifugation and dialysis.; Study of desalting out of proteins; Separation of proteins using HPLC and quantify the fractions.; Separation of binary protein complex using FPLC; Separation of protein complex using sucrose gradient method; Separation of proteins using Electrophoresis methods; Isolation of DNA using from cell extract; Separation of various molecular weight proteins using reverse osmosis and ultrafiltration techniques.

BM 373	ENVIRONMENTAL BIOTECHNOLOGY LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Determination of electrical conductivity and alkalinity of waste water; . Determination of dissolved oxygen in water samples; Determination of Biochemical oxygen demand in water samples; . Determination of Chemical oxygen demand in water samples; Determination of Total suspended solids (TSS) and total dissolved solids (TDS) in water samples; Microbial degradation of phenol; Microbial degradation of chromium; Determination of toxic metal contents in industrial effluents; Adsoption through activated carbon for waste water treatment; Analysis of CO & NOx in air samples; Analysis of Bacteria, fungi, mold and pollen present in air samples; Determination of Organic Matter and Acidity of soil sample; Isolation of microflora from soil samples collected different area; Biosorption of heavy metals from aqueous solution of metals; Determination of Cation exchange capacity of soil sample

BM 374	BIOCHEMICAL ENGINEERING LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Isolation of useful microorganisms from natural samples; Growth of microorganisms, estimation of Monod parameters; Temperature effect on growth-estimation of energy of activation and Arrhenius; . Constant for microorganisms.; Study of growth kinetics of bacteria in shakeflask.; Separation of protein using sucrose gradient method.; Separation of proteins using Electrophoresis methods.; Separation of DNA using Electrophoresis method.; Separation of protein using reverse osmosis.; Study of growth kinetics saccharomyces cerevisiaein shakeflask.; Estimation of dry cell mass.; Study of growth kinetics of bacteria in bioreactor.; Death kinetics of saccharomyces cerevisiae.

BM 375	BIOHEAT AND MASS TRANSFER LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Thermal conductivity of liquids; Heat transfer through a stacked layer.; Parallel flow and counter flow heat exchanger. Effective insulation. Determination of Stefan Boltzmann constant. Unsteady heat transfer. Dropwise and Filmwise Condensation Apparatus. Mass transfer with or without chemical reaction; Cryospray. Determination of diffusion constants.

BM 376	BIOPROCESS INSTRUMENTATION LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

To study the principle, calibration and measurement of pH using a digital pH meter.; To study the working principle of turbidimeter and determine the turbidity of an unknown solution. To study the operation of conductivity meter and find out the conductance of an unknown solution. To determine the dynamic and kinematic viscosity of the Newtonian fluids using Ostwald's viscometer. To determine the surface tension of a liquid using Stalagmometer by (a) drop count method and (b) drop weight method. To determine the critical micelle concentration of tween 80 using Stalagmometer. To study the working principle of UV-Vis spectrophotometer and to find out the concentration of an unknown sample. To prepare emulsions by wet gum method and to determine the droplet size distribution by developing a program in NI Vision 2010. To acquire and save analog signals in computer using ADCs. To study the operation of optocouplers in signal isolation. To find out the melting point of a given sample using melting point apparatus. Temperature measurement using semiconductor temperature sensors. To study the principle of impedance spectroscopy.

BM 378 ANIMAL CELL CULTURE AND IMMUNOTECHNOLOGY LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Preparation of cell culture media, Cell counting by hemocytometer, Cell viability study by trypan blue exclusion method, Cell passage, Primary cell culture; Cell viability study by MTT assay method, FACS based live/dead study using DIO/PI, Cell cycle analysis, LPS induced macrophage activation study by nitric oxide estimation, ELISA, Immuno-histochemical analysis of cellular F-actin distribution, MACS based sorting of CD4/CD8 cells from total splenocyte population, FACS based sorting of CD4/CD8 cells from total splenocyte population, Endocytosis study.

BM381 BIOMATERIAL LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Determination of hardness of different implant materials by Vickers Indentation. Determination of tensile strength of implant materials. Determination of modulus of rigidity of different biomaterials. Extraction of biopolymers from plants by HPLC method. Estimation of haemocompatibility of biomaterials by hemolysis studies; To study the influence of surface roughness on the wetability of the implant material. Determination of surface energy of different biomaterials through contact angle measurement. Determination of glass transition temperature of polymer and polymer composite. Measurement of rheological properties of polymer solution and simulated of body fluid. Determination of moment of inertia of human bone using compound pendulum method. Determination of roughness of different implant materials. Determination of coefficient of friction and wear resistance of different implant surfaces. Study the pitting corrosion behavior of stainless steel in simulated body fluid. Determination of corrosion rate of Titanium implant in simulated body fluid

BM 382 BIOMEDICAL IMAGE PROCESSING LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Image enhancement–Histogram; Image smoothing, Image sharpening; Lowpass filter, highpass filter, median filter; Point detection, Line detection; Edge detection, Prewitt Edge, quich Edge detector; Mathematical operation on images; Image data compression; Implementation of the TWO Dimensional F.F.T. Batchprocessing of manufactured medical devices; Continuous monitoring of the manufactured medical devices; Particle size analysis; Image registration; Volume reconstruction; Determination of the color-coded parts in a given device; Inspection of devices using gauging; Cell culture analysis; Inspection of the PCB components; Edge detection as a tool for connector pin inspection; Inspection of the blister packs; Dental floss inspection; Pills inspection using watershed algorithm; Tablet discoloration inspection; Foreign tablet inspection; Label Inspection; Determination of the dents on the medical devices; Calibration of the Bordon Pressure Tube using image processing and analysis tools

BM 383 BIOMEDICAL SIGNAL PROCESSING LABORATORY - I 2 credits [0-0-3]

Prerequisites: NIL

Introduction to LabVIEW., Signal acquisition using ADC cards, Determination of the frequency components in a given signal using FT, Design of DSP Program to Measure distance with help of acoustics, Design of Acoustic LED Volume Unit Meter, Design of AM Modulation, Design of FM Modulation, Design of Automatic gain Control using SPEEDY 33, Design of Bandstop Filter and deployment on to SPEEDY 33, Design of Biquad Filter and deployment on to SPEEDY 33, Design of Blink LED, Design of DTMF decoder and deployment on to SPEEDY 33, Design of FFT Bit Twiddling, Design of Fourier series on SPEEDY 33, Design of FSK Modem, Design of heterodyne filter, Design of LED Cross Correlation, Design of LMS Filter, Design of QPSK, Simple Convolution using SPEEDY 33, Speech Pitch Modifier using SPEEDY 33, Designing of Windowing Techniques, Design of Fourier Transform, Design of Discrete Time Signals, Discrete Fourier Transforms using SPEEDY 33. Z-Transforms on SPEEDY 33, Digital Filter Design using SPEEDY 33, Design of IIR Filter. FIR Filter Design on SPEEDY 33, Create a Virtual Instrument to Write a string on to display of Arm Cortex LM3S8962, Create a Virtual Instrument to measure Temperature and display on Arm Cortex M3, Create a virtual instrument to measure heart rate and display on ARM cortex M3, Create a Virtual Instrument to display Health monitoring conditions of Patient, Create a Virtual Instrument to Acquire and measure small voltage signals, Create a program to build etch a sketch game using Arm Cortex, Program to control Speed of Motor on ARM cortex

BM 384 BIOMEDICAL INSTRUMENTATION LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Designing of a window comparator, Designing of a voltage buffer, Designing of a differential amplifier and improvement of its CMRR, Designing of a bio potential lamplifier, Comparison of the input impedances of a differential amplifier and a bio potential amplifier, Designing of a bio potential amplifier using 2 OPAMPS, To design a voltage-current converter and to study its importance in signal transmission, To design V-F and F-V converters, To study the signal transmission properties of a MCT2E optocoupler, To design precision half-wave and full-wave rectifiers, Designing of precision peak and valley detectors.

BM 385 MEDICAL EQUIPMENT DESIGN LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

To study the functioning of aspirometer, To develop a biofeedback system, To develop a continuous temperature monitoring system, To design an impedance spectroscope, To design an online heart rate monitoring system, To design a continuous humidity monitoring system, To design a low cost sphygmomanometer, To design a low cost stethoscope, To design an ECG amplifier.

BM 386 EXPERIMENTAL BIOMECHANICS LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Determination of stress strain curve for hard tissues (bone/ metallic implants), Determination of stress strain curve for soft tissues (scaffolds/ chitosin/etc), Determination of compressive strength for metallic biomaterials, Determination of flexural strength using 3-point bend fixture, Effect of stiffness/young's modulus on stress shielding, Cyclic fatigue testing of hard tissues, Biomechanical torsion test on long bones, Study on wear characteristics of various metallic implants

BM 387 BIOMEDICAL SIGNAL PROCESSING LABORATORY- II 2 credits [0-0-3]

Prerequisites: NIL

Manipulation of signals as per a given mathematical equation, Data compression, Extraction of a signal portion, Basics of filtering techniques., Implementation of FIR and IIR filters and study their characteristics Designing of notch filter to eliminate 50 Hz noise, Designing of comb filter to eliminate 50 Hz noise and its harmonics, Signal averaging as a tool to improve SNR, Implementation of an adaptive filter for noise cancellation, Instrumentation of amplifier to acquire ECG Signals, Signal Processing of ECG Signals and Measuring Heart Rate, Spectrum analysis of Noisy and pure Biosignal, Time domain and Frequency Domain Measurements on Biosignals, Design of a Biosignal Logger, Implementation of a program for designing a biofeedback system on EMG, Implementation of a program to drive DC motor using EMG signal. (DC Drive Should be designed on own)

BM 401 HOSPITAL MANAGEMENT 3 credits [3-0-0]

Prerequisites: NIL

Classification of Hospital systems, Role of biomedical engineers; Aspects of hospital services- outpatient- inpatient supportive emergency drug and medical supply nursing dietary service transport services; Hospital planning –location, orientation, budgeting, inside & outside communication, electric power supply for various theatres and rooms, diesel generator, standby power supply; Air-conditioning of important theatres and equipment housings, water supply requirements and management, lifts, fire fighting equipments. Sanitation, laundry services; Computer and information management in hospitals: computer aided hospital management: application administration / discharge records of patient's patients billing – maintenance of patient's records, their history, maintenance of inventory of medicines and drugs- purchase; Electrical factors in hospital design, voltage stabilizer, uninterrupted powersupply for intensive care units and computerized monitoring units-safety precautions, protection, grounding of ECG, EEG, ENG and other therapeutic equipments; Biomedical equipment services their purchase, servicing and maintenance of equipment, training of men for medical equipments, preventive and periodical maintenance procedure.

Essential Reading:

1. S I Goel and R Kumar, ***Hospital administration and management***, Deep and Deep pub. NewDelhi, 2002
2. L. E. Swayne, J. Duncan and P. M. Ginter, ***Strategic Management of Health Care Organizations***, Wiley-Blackwell; 5 edition 2007

Supplementary Reading:

3. Sahni, ***ISHA sourcebook of modern technology for hospitals and health care***, Bangalore, 1992
4. M. Nowicki, ***The Financial Management of Hospitals and Healthcare Organizations***, Health Administration Press; Fourth edition, 2007

BM 402	HEALTH INFORMATICS	3 credits [3-0-0]

Prerequisites: NIL

Planning and designing of hospital systems: financial aspects, equipment, building, organization, medical services, BME services and technical aspects: pole & responsibilities layout, setting and functions of BME department in a hospital. Biomedical Equipment management; Data base management: introduction to data structure, elements, arrays, records, sets, tables, singly and doubly linked data, stacks, queues and trees, Architecture of DBMS. Representation of data, physical record interface, datamodels, relational, Hierarchical and network approach; Data modeling techniques: relational, Hierarchical and network normalization techniques, Data indexing and structuring techniques, integrity and security of database, information searching and retrieval; Hospital information system: computerization & functional capabilities of a computerized hospital information system. Cost effectiveness of using computer, security of computer records source of data for decision making, Computerized patient database management, Microprocessors, database approach to laboratory computerization; Application of artificial intelligence in medicine; Telemetry application in Medicine: Telemetry circuits, modulation systems, single and multi channel telemetry system, implantable telemetry system, wireless telemetry, video conferencing, tele- surgery, virtualreality.

Essential Reading:

1. R D Lele, ***Computers inmedicine***, Tata McGrawHillPub, NewDelhi, 1998.
2. GDKunders, ***HospitalPlanningDesignandManagement***, TATAMcGrawHill Pub. New Delhi, 2003

SupplementaryReading:

1. C JDate, ***An introduction todatabasesystems***, 8th edition, AddisonWesley2003
2. JD Ullman, ***Principles of databasesystem***, Galgotia Pub. 1990.
3. RSKhandpur, ***Handbookofbiomedicalinstrumentation***, TataMcGrawHillPub, 2nd eds, NewDelhi, 2003

BM 403	HOSPITAL ENGINEERING AND INFORMATION SYSTEM	3 credits [3-0-0]

Prerequisites: NIL

Classification of hospital & architecture, Aspects of hospital services–inpatient, outpatient and emergency. Location & environment of hospital, Hierarchy of medical and paramedical staff & their functions and responsibilities. Modern Hospital Architecture; Electrical power systems in hospitals: Safety of electrical systems, Protective systems. Design of sub stations, breakers, Surgeprotectors, EMI filters, voltagestabilizers, generatorsets and UPS. Uninterrupted power supply for ICU and computerized monitoring units. Specification & estimation for hospital wiring - small case study Air conditioning & gas supply systems: Air conditioning & refrigeration systems, air changes, filtering & sterility, deodorization, disinfection, dehumidification & cryogenicsystems. Centralized supply of air, oxygen, nitrous oxide & vacuum, Management of lifts, fire fighting equipments; Hospital engineering & Management: Definition of biomedical, clinical & hospital engineering, Importance and function of BME department, Importance of ISO 9000 Certificates in hospitals; Hospital Information system: Role of database, Need & Overview of Networking, topologies and its configuration. Structuring medical records, Computerization in pharmacy & billing. Automated clinical laboratory systems & radiology information system.

Essential Reading:

1. Rudi Van De Velde and P. Degoulet, ***Clinical Information Systems: AComponent- Based Approach***, Springer; 1stedition, 2003
2. A. K. Saini, ***Management Information System in Hospitals***, Deep & Deep Publications, India, 2002

SupplementaryReading:

1. T. S. Hargest, C. A. Caceres, G. Hammer, J. L. Williams, ***Management and Clinical Engineering***, Artech House, 1980
2. A . Narayanan, ***Basic Refrigeration and Air Conditioning***, McGraw-Hill Education, 2005
3. H. E. Smalley, ***Hospital Management Engineering – A guide to the improvement of hospital management system***, PHI. 1982

BM 405	TELEMEDICINE	3 credits [3-0-0]

Prerequisites: NIL

History of Telemedicine, Block diagram of telemedicine system, Telehealth, Telecare, Origins and Development of Telemedicine, scope, benefits and limitations of Telemedicine; Types of information: Audio, Video, StillImages, Text & data, Fax. Types of Communication & Network: PSTN, POTS, ATN, ISDN, Internet, Wireless communications, Different modulation techniques. Types of antennas, Integration and Operational issues, real-time Telemedicine; Data Exchange: Network Configuration, Circuit and packet switching, H. 320 series (Video phone based ISBN)T. 120, H. 324(Video phone based PSTN), Video Conferencing; Data Security and standards: Encryption, Cryptography, Mechanisms of encryption, Phases of Encryption, Protocols: TCP/IP, ISO-OSI, Standards to followed DICOM, HL7; Ethical and legal aspects of telemedicine; Teleradiography: Basic parts of teleradiology system, Telepathology-Multimedia databases, colorimages of sufficient resolution: Dynamic range, spatial resolution, compression methods, Interactive control of color, control ledsampling, security and confidentiality tools. Tele cardiology, Teleoncology, Tele surgery.

Essential Reading:

1. A. C. Norris, ***Essentials of Telemedicine and Telecare***, John Wiley & Sons, 2002
2. R. Wootton & Victor Patterson, ***Introduction to Telemedicine***, RSM Press, 2006

Supplementary Reading:

1. Olga Ferrer-Roca & M. Sosaludicissa, ***Handbook of Telemedicine***, IOS Press 2002
2. A. Darkins & M. Cary, ***Telemedicine and Telehealth: Principles, Policies, Performance and Pitfalls,*** Springer Publishing Company; 1stedition, 2000
3. R. Latifi, ***Current Principles and Practices of Telemedicine and e-Health: Volume 131 Studies in Health Technology and Informatics,*** IOS Press; 1stedition, 2008

BM 411	MEDICAL EMBEDDED SYSTEM	3 credits [3-0-0]

Prerequisites: NIL

Memory interfacing ROM and SRAM; I/O interfacing: I/O mapped I/O scheme. SimpleI/Oports (8282); Peripherals interfacing: Matrix key board, 7-segment LED's, DAC, ADC, Getronics parallel; printer, CRT data terminal; Interfacing of 8086 with programmable peripheral interfacechip(8255), Programmable; communicator chip(8251), Programmable Internal timer chip (8253), Programmable; interrupt controller(8259), DMA(8257) controller; Interfacing applications of 8051 –ADC, DAC, Elevator and simulator, 7-segment display, traffic light controller, LEDdisplay, keyboard interfacing; Interfacingapplication of PIC-Analog to digital module, power down (sleep) modes; Programming of PIC, Standard I/O and processor directives, CCS-PIC COMPILER; Interfacing of medical sensors, carbondioxide and oxygen sensors, respiration, force, flow, differential voltage and current probes and humidity sensors.

Essential Reading:

1. R. J Goankar, ***Microprocessor architecture, programming and application with 8085***, 4th Ed., Penram International Publishing, 1999.
2. K. J. Ayala, ***The 8051 Microcontroller-Architechture, Programming and Applications***, 2nd Ed., Penram International Publishing, 2005.

Supplementary Reading:

1. R. Barnett, L. O' cull and S. Cox, ***Embedded C programming and the microchip PIC***, Thomson Learning, 2004
2. T. Noergaard, ***Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers,*** Newnes 2005

BM 413	MEDICAL IMAGING	3 credits [3-0-0]

Prerequisites: NIL

X-rays production & properties, various components of radiographic systems, rating charts of X- ray tubes. Electrical circuit for X-ray m/c, filament circuits and mA control, HT circuits, KV control, control of exposure timers, collimators, scatter & grids, absorbed dose, basics of tables & arms, dark room accessories, types of X-ray tubes for various medical applications; Principle of photography and radiographic film image, film sensitometry, information content of an image, image quality factors, MTF. Detectors-ionization chamber, proportional counter, Geiger- Muller counter scintillation detectors, semiconductor radiation detector, Image intensifier, automatic brightness control system, image distortion and artifacts; Fluoroscopic imaging system, principle, specific system design. Digital fluoroscopy-c-arm system. Digital subtraction angiography (DSA), digital subtraction programming; Radiotherapy principles, dosage atafor clinical applications, radiation therapy planning, collimatorsandbeamdirection devices, dose measurement and treatment planning, teleisotope units. Safety protocols & protection; Physics of thermography, Imaging systems, clinical thermography, liquid crystal thermography Special imaging techniques.

Essential Reading:

1. W. R. Hendee and E. R. Ritenour, ***Medical Imaging Physics***, 3rd editions, Mosbey Year-Book, Inc., 1992.
2. J. T. Bushberg, J. Anthony Seibert, E. M. Leidholdt Jr., J. M. Boone, ***The Essential Physics of Medical Imaging***, 2nd Edition, Lippincott Williams & Wilkins, 2001

Supplementary Reading:

1. R. C. Gonzalez and R E Woods, ***Digital image processing***, 2nd ed. Prentice Hall, 2002.
2. P. Suetens, ***Fundamentals of image processing***, Cambridge University Press, 2002.
3. Dowsett, Kenny & Johnston, ***The Physics of Diagnostic Imaging***, Chapman & Hall Medical, Madras/London, 1998
4. R. Salzer, ***Biomedical Imaging: Principles and Applications,*** Wiley-Interscience, 2008

BM 415	ELECTRONIC DEVICES FOR REHABILITATION ENGINEERING	3 credits [3-0-0]

Prerequisites: NIL

New technologies in rehabilitation engineering, retinal prosthesis for the visually impaired, intelligent techniques for the hearing impaired, sensory feedback for lower limb prosthesis, multifunctional control of prostheses using myoelectric signals, neural prostheses, upper limb myoelectric prostheses, artificial heart control using computer-aided support technologies, diaphragm pacing, intelligent systems for pacemakers, service robots, mobility devices for the blinds and visually impaired, design concepts of KAFO.

Essential Readings:

1. Hisaichi Ohnabe and Douglas A. Hobson, ***An Introduction to Rehabilitation Engineering,*** Publisher: Taylor & Francis; 1 edition, ISBN-10: 0849372224, ISBN-13: 978-0849372223.
2. Horia-Nicolai L Teodorescu and Lakhmi C. Jain, ***Intelligent Systems and Technologies in Rehabilitation Engineering***, Publisher: CRC Press; 1 edition, Language: English, ISBN-10: 0849301408, ISBN-13: 978-0849301407.

Suggested Readings:

1. Rory A. Cooper, ***Rehabilitation Engineering Applied to Mobility and Manipulation (Series in Medical Physics and Biomedical Engineering),*** Publisher: Taylor & Francis; 1 edition, ISBN-10: 0750303433, ISBN-13: 978-0750303439.
2. AbdelsalamHelal, MounirMokhtari and BessamAbdulrazak, T***he Engineering Handbook of Smart Technology for Aging, Disability and Independence,*** Publisher: Wiley-Interscience; 1 edition, ISBN-10: 0471711551, ISBN-13: 978-0471711551.

BM 421	TISSUE ENGINEERING	3 credits [3-0-0]

Prerequisites: NIL

Introduction, structural and organization of tissues: Epithelial, connective; vascularity and angiogenesis, basic wound healing, cell migration, current scope of development and use in therapeutic and in-vitro testing; Cell culture-Different cell types, progenitor cells and cell differentiations, different kind of matrix, cell-cell interaction. Aspect of cell culture: cell expansion, cell transfer, cell storage and cell characterization, Bioreactors; Molecular biology aspect-Cell signaling molecules, growth factors, hormone and growth factor signaling, growth factor delivery in tissue engineering, cell attachment: differential cell adhesion, receptor-ligand binding, and Cell surface markers; Scaffold and transplant- Engineering biomaterials, Degradable materials, porosity, mechanical strength, 3-D architecture and cell incorporation. Engineering tissues for replacing bone, cartilage, tendons, ligaments, skin and liver. Basic transplant immunology, stemscells; Casestudy and regulatory issues– cellt ransplantation for liver, musculoskeletal, cardiovascular, neural, visceral tissue engineering. Ethical FDA and regulatory issues.

Essential Reading:

1. B. Palsson, S. Bhatia, ***TissueEngineering,*** PearsonPrenticeHall, 2003
2. G. Vunjak-Novakovic, R. Ian Freshney, ***Culture of Cells for Tissue Engineering***, WIS, 2006

SupplementaryReading:

1. B. Palsson, J. A. Hubbell, R. Plonseyand J. D. Bronzino, ***TissueEngineering***, CRC- Taylor & Francis.
2. J. D. Bronzino, ***TheBiomedical Engineering–Handbook***, CRC; 3rd edition, 2006
3. R. P. Lanza, R. LangerandW. L. Chick, ***Principles of tissueengineering***, Academic press, 1997

BM 422	COMPUTER APPLICATION IN TISSUE ENGINEERING	3 credits [3-0-0]

Prerequisites: NIL

Anatomic and Biophysics Modelling, Geometric Morphology, Volumetric Representation, Mechanics deformation Kinetics, CAD based Modelling, Counter based Modelling, Surface Extraction, Solid Model, Biomedical Physical Modelling, Physical model by rapid prototyping. Scaffold informatics and Biomimetic Design and Modelling, Tissue morphology classification and characterization, Biological intent, Informatics database and modelling, Biomimetic Design, Design for multi-constraints, A framework for Biomimetic design, Mutiscalemodelling for Biological system, Asymptomatic homogenization for both spatial and temporal degradation. Bio-manufacturing for Tissue scaffolds, Bio-conductive scaffolds fabrication, Multilateral hybrid scaffold, Smart scaffold with micro/nano sensor, Bio-manufacturing for Tissue constructs, Scaffold with anatomic cell seeding, Cellular tissue threads, Cell-embedded, 3d cells and organ printing, Cell pattern, printing and deposition, Bio-blue printing and organ modelling, Organ printing

Essential Reading:

1. R. P. Lanza and J. Vacanti: ***Principles of tissue engineering,*** Academic Press 2007, ISBN: 0123706157
2. U. Meyer, J. Handschel, T. Meyer and H. P. Weismann: ***Fundamentals of tissue engineering and regenerative medicine:*** Springer Verlag, 2009 ISBN: 3540777547

Supplemental Reading:

1. P. R. Fernandes; ***Advances on Modeling in Tissue Engineering*** : Springer Verlag, 2011 ISBN: 9400712537
2. C. S. S. R. Kumar: ***Tissue, cell and organ engineering,*** Wiley-VCH, 2006, ISBN: 9783527313891

BM 423	NANOTECHNOLOGY IN TISSUE ENGINEERING	3 credits [3-0-0]

Prerequisites: NIL

Nanotechnology in tissue engineering, Scaffold based Approach, Polymeric nanofibers in Tissue Engineering, Synthetic polymers, Biopolymers, Synthesis of nanofibers by different methods, Application of polymeric nanofibers in tissue engineering. Synthesis, biological effects of nanofibers- attachment, proliferation, differentiation, migration. Problems with current implants, ceramic nano materials, metal nano materials, polymeric nano materials, composite nanomaterials. Magnetic nanoparticles for tissue engineering. Carbon nano tube in tissue engineering. Nano wires for tissue engineering.

Essential Reading:

1. K. Popat, ***Nanotechnolgy in tissue engineering and regenerative medicine,*** CRC, 2009, ISBN: 143980141X
2. H. F. Tibbals***Medical Nanotechnology and Nanomedicine*** CRC Press2010 ISBN: 1439808740

Supplemental Reading:

1. J. M. Polak, ***Advances in tissue engineering*** Imperial College Pr2008 ISBN: 1848161824

BM 424	ARTIFICIAL ORGANS AND REHABILITATION ENGINEERING	3 credits [3-0-0]

Prerequisites: NIL

Introduction to artificial organs: Biomaterials used in artificial organs and prostheses, Rheological properties of blood, blood viscosity variation, Casson equation, flow properties of blood, problems associated with extra corporeal blood flow; Artificial kidney: kidney filtration, artificial waste removal methods, hemodialysis, equation for artificial kidney and middle molecule hypothesis. Hemodialysers, mass transfer Analysis, regeneration of dialysate, membrane configuration, wearable artificial kidney machine, separation of antigens from blood in ESRD patients; Artificial heart-lung machine: lungs gaseous sexchange/ transport, artificial heart-lung devices. Oxygenators, Liver support system, artificial pancreas, blood and skin; Audiometry: air conduction, bone conduction, masking, functional diagram of an audiometer. Hearing aids, Opthalmoscope, etinoscope, I. A. B. P principle and application; Rehabilitation Engineering: Impairments, disabilities & handicaps, measurement & assessment, engineering concepts in sensory & motor rehabilitation. Engg. Concept in communication disorders, Rehabs for locomotion, visual, speech & hearing, Artificial limb & hands, prosthetic heart valves, Externally powered & controlled orthotics & prosthetics, Myoelectric hand & arm prostheses, marcus intelligent hand prostheses, gait study, spinal rehabilitation.

Essential Reading

1. Gerald EMiller, ***Artificial Organs,*** Morgan & Claypool, 2006
2. Kondraske, G. V, ***Rehabilitation Engineering.*** CRC press1995

Supplementary Reading

1. Bronzino Joseph, ***Hand book of biomedical Engineering,*** Springer, 2000
2. R. S. Khandpur, ***Biomedical Instrumentation: Technology and Application,*** McGraw-Hill Professional

BM 425	BIOMATERIALS IN TISSUE ENGINEERING	3 credits [3-0-0]

Prerequisites: NIL

Introduction to biomaterials, Types of biomaterials, Biocompatibility testing of biomaterials, Surface characterization methods, Cells interaction with biomaterials. Scaffold fabrication methods: fiber bonding, electrospinning, solvent casting, and particulate leaching, melt molding, freeze drying, phase separation, Rapid prototyping. Micro and nano fabricated Scaffolds. Three dimensional scaffolds- Design and engineering, Smart biomaterial.

Essential Reading:

1. J. A. Burdick ***Biomaterials for Tissue Engineering Applications*** Springer Verlag2010 ISBN: 3709103843

Supplemental Reading:

1. E. Jabbari Biologically-Responsive Hybrid Biomaterials: ***A Reference for Material Scientists and Bioengineers*** World Scientific Publishing Company 2010 ISBN: 9814295671
2. C. Gualandi Porous Polymeric ***Bioresorbable Scaffolds for Tissue Engineering*** Springer Verlag 2011 ISBN: 3642192718

BM 427	BIOCOMPOSITES	3 credits [3-0-0]

Prerequisites: NIL

Introduction, biocompatibililty, fabrication(filament winding, pultrusion, extrusion, injection molding, compression molding, thermoforming) and characterization, mechanics of composite materials, structure-property relationship, designing with composite materials, Biomedical application of polymer composites- bone plates, intramedullary nails, total hip replacement, bonegrafts, denatsl materials, prosthetic sockets, tendons and ligaments, vascular grafts.

Essential Reading:

1. S. H. Teoh, ***Engineering Materials for Biomedical Applications,*** World ScientificEdition1, 2004.
2. S. Ramakrishna, ***An Introduction to Biocomposites,*** Imperial College Press; Edition 1, 2004

Supplementary Reading:

1. B. D. Ratner, A. S. Hoffman, F. J. Schoen, J. E. Lemons, ***BiomaterialsScience,*** Academic Press, Edition1, 1996.
2. J. Y. Wong, J. D. Bronzino, ***Biomaterials,*** CRC Press, Edition 2007

BM 428	NANOTECHNOLOGY IN BIOMEDICAL ENGINEERING	3 credits [3-0-0]

Prerequisites: NIL

Nanotechnology-, nanodefinitions, unique properties of nanoscalematrices. Chemical Routes for Synthesis of Nanomaterials, Nanocomposites, Types of Nanocomposite (i.e.metal oxide, ceramic, glass and polymer based); Core-Shell structured nanocomposites Superhard Nanocomposite. Nanopolymers: Preparation and characterization, Metal Nanoparticles: Size control of metal Nanoparticles and their characterization; Nano fabrication: Nanolithography, E beam lithography, Ion beam lithography etc. Nanoparticles Synthesis- Methods of Preparation, top down and bottom up approach, Characterization methods, Properties and size effect of nanomaterials, electrical, Mechanical, Magnetic, Optical and catalytic properties, Cluster compounds, quantum-dots from MBE and CVD, wet chemical methods, Nanofiber synthesis- electrospin fibers, self assemblefibers. Advanced Nanomaterials: Fundamentals of magnetic materials, Carbon Nano Structures: Introduction; Fullerenes, C60, C80 and C240 Nanostructures; Properties & Applications (mechanical, optical and electrical). Preparation of Carbon Nano-Tubes: Properties, Applications. Characterization Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, X-ray diffraction, Optical Microscope and their description, operational principle and application for analysis of nanomaterials. Biomedical Applications – drug delivery, tissue regeneration, cancer detection, imaging and diagnostics, outlook for future.

Essential Reading:

1. G. Cao, ***Nanostructures and Nanomaterials: Synthesis, Properties and Applications,*** Imperial College Press, 2004.
2. M. Winterer***, Nano-crystalline Ceramics: Synthesis and Structure***, Springer, 2002

Supplementary Reading:

1. M Wilson, K Kannangara, G Smith and M Simmons***, Nanotechnology: Basic Science and Emerging Technologies***, Chapman and

Hall, 2002

2. M A. Ratner, D Ratner, M Ratner, ***Nanotechnology: A Gentle Introduction to the Next Big Idea,*** Prentice Hall PTR, 2002.

BM 429	MATERIALS IN MEDICAL SCIENCE	3 credits [3-0-0]

Prerequisites: NIL

Introduction: Definition of biomaterials, classification of biomaterials properties of materials, mechanical properties; Metallic implant materials: Definition. Stainless steel, Co-basedalloys, Ti and Ti-based alloys. Polymeric implant materials: Natural and arftificial biopolymers; Ceramic implant materials: Definition. Bioresorbableandbioactive ceramics. Aluminiumoxides, Glass ceramics, Carbons. Composite implantmaterials: Definition, Properties and applications. Biocompatibility & toxicological screening of biomaterials.

Essential Reading:

1. B D. Ratner, AS. Hoffman, FJ. Schoen, JE. Lemons, ***Biomaterials Science:*** Academic Press, 1stEdition, 1996.
2. S HTeoh, ***Engineering Materials for Biomedical Applications,*** World Scientific: 1st Edition, 2004.

SupplementaryReading:

1. J B. Park, JD. Bronzino, ***Biomaterials: Principles and Applications***; Taylor & Francis, Edition1, 2002.
2. JY. Wong, J D. Bronzino, ***Biomaterials,*** CRC Press, Edition 2007

BM 431	PHYSIOLOGICAL SYSTEM MODELING	3 credits [3-0-0]

Prerequisites: NIL

Techniques of mathematical modeling, classification of models, characteristics of models. Purpose of physiological modeling and signal analysis, linearization of nonlinear models, Time invariant and time varying systems for physiological modeling; Electromotive, resistive and capacitive properties of cell membrane, change in membrane potential with distance, voltage clamp experiment and Hodgkin and Huxley's model of action potential, the voltage dependent membrane constant and simulation of the model, model for strength-duration curve, model of the whole neuron. Huxley model of isotonic musclecontraction, modeling of EMG, motor unit firing; Electrical analog of blood vessels, model of systematic blood flow, model of coronary circulation, transfer of solutes between physiological compartments by fluid flow, counter current model of urine formation, model of Henle'sloop, and Linearized model of the immune response: Germ, Plasma cell, Antibody, system equation and stability criteria.

Essential Reading:

1. Endarle, Blanchard & Bronzino, ***Introductionto Biomedical Engg.,*** Academicpress. 2005
2. S. R. Devasahayam, ***Signals & Systems in Biomedical Engineering***, Springer, 2000

Supplementary Reading:

1. J. Candy, ***Signal Processing: The Model Based Approach***, Mc. GrawHill, 1986
2. L. Stark, ***Neurological Control System***, PlenumPress, 2007

BM 432	BIOMICROFLUIDICS	3 credits [3-0-0]

Prerequisites: NIL

Introduction, Microfluidics vs traditional fluidics, Microfluidic systems in nature, Fundamental principles, Concept of biomicrofluidics, different transport phenomena in biomimetic micro fluidic system, Micro mixing and biochemical reaction in microfluidic platform, Concept of 'Lab on a chip', Mathematical modeling of transport phenomena and micromixing of biomimetic microfluidic processes, Micro-manupulation of biomicrofluidic system using electric and magnetic field, Microfluidics in Tissue Engineering, Experimental approaches in biomicrofluidics, Future prospect.

Essential Reading

1. S. Chakraborty, ***Microfluidicsand Microfabrication***, Springer
2. P. Tabeling, ***Introduction to microfluidics***, Oxford University Press

Supplementary Reading

1. J. D. Zahn, ***Methods in Bioengineering: Biomicrofabrication andBiomicrofluidics***, Artech House.
2. F. A. Gomez, ***Biological application of microfluidics***, John Wiley & Sons
3. J. Berthier and P. Silberzan, Microfluidics for Biotechnology, Artech House

BM 433 BIOTRANSPORT 3 credits [3-0-0]

Prerequisites: NIL

A review of thermodynamic concepts: open systems, closed systems, phase equilibrium. Physical properties of the body fluids and the cell: fluid composition, osmotic pressure, the cell membrane. Physical and flow properties of blood and other fluids: blood rheology, Hagan-Poiseuille equation, the Casson equation, Marginal zone theory, boundary layer theory. Solute transport in biological systems: Fick's first and second laws, mass transfer in laminar boundary layer flow, solute transport by capillary filtration, solute diffusion within heterogeneous media, solute permeability, transport of solutes across the capillary wall, The Krogh tissue cylinder. Oxygen transport in biological systems: diffusion of oxygen in multicellular systems, oxygen-haemoglobin dissociation curve, The Hill equation, oxygen transport in the Krogh tissue cylinder. Approach to pharmaco kinetic modeling and drug delivery, one and two compartmental models. Physiological applications-itravenous injection, constant intravenous infusion, determination of regional blood flow volumes and blood flow rates.

Essential Reading:

1. R. Fournier, ***Basic Transport Phenomena in Biomedical Engineering***, Taylor & Francis; 2 edition, 2006
2. A. T Johnson, ***Biological Process Engg. An analogical approach to fluid flow, heat transfer, mass transfer applied to biological system***, John Wiley and Sons1999.

SupplementaryReading:

1. A. B. Ritter, S. Reisman, B. B. Michniak, ***Biomedical Engineering Principles***, CRC Press, 2005
2. D. O. Cooney, ***Biomedical Engineering Principles- An introduction to fluid, heat and masst ransfer processes***, Marcel Dekker Inc. 1976.

BM 441 PROTEIN ENGINEERING 3 credits [3-0-0]

Prerequisites: NIL

Protein - general introduction, forces that determine protein structure and physicochemical properties. Mechanisms of protein folding, molten globule structure, characterization of folding pathways. Determination of protein structure by various spectroscopic techniques. Background and basic principles, Absorption and Fluorescence, Circular Dichroism, FT-Raman, FT-IR, NMR, X-raycrystallography, MALLS. Thermal properties of proteins and application of DSC. Protein denaturation, aggregation and gelation. Flow properties of proteins and sensory properties of proteinaceous foods. Protein functionality. Protein raw materials-cereals, legume, oilseeds and pseudo cereals. Muscle protein, Milk protein, Egg protein. Protein modification as result of technological processes: thermal, enzymatic, physical, pressure, solvents, interactions. Nutritive role of food proteins.

Essential Reading:

1. 1. J L. Cleland andC S. Craik, ***Protein Engineering: Principles and Practice,*** Wiley-Liss, ISBN-13: 978-0471103547, 1stedition, February7, 1996.

Supplementary Reading:

1. S Lutz and UT Bornscheuer, ***Protein Engineering Handbook,*** Wiley-VCH, ISBN-13: 978-3527318506, Newedition, January20, 2009.

BM442 CANCER BIOLOGY 3 credits [3-0-0]

Prerequisites: NIL

Regulation of Cell cycle, mutations that cause changes in signal molecules, effects on receptor, signal switches, tumoursuppressor genes, modulation of cell cycle in cancer. Different forms of cancers, Diet and cancer. Chemical Carcinogenesis, Metabolism of Carcinogenesis, Natural History of Carcinogenesis, Targets of Chemical Carcinogenesis; Principles of Physical Carcinogenesis, X - Ray radiation - mechanism of radiation Carcinogenesis. Oncogenes, Identification of Oncogenes, Retroviruses and Oncogenes, detection of Oncogenes, Growth Factor and Growth Factor receptors that are Oncogenes; Oncogenes / Proto Oncogene activity. Growth factors related to transformations. Clinical significances of invasion, heterogeneity of metastatic phenotype, Metastatic cascade, Basement Membrane disruption, Three-step theory of Invasion; Proteinases and tumourcell invasion. Detection of Cancers, Prediction of aggressiveness of Cancer, Advances in Cancer detection. Different forms of therapy, Chemotherapy, radiation Therapy, and Immuno therapy: advantages and limitations.

Essential Reading:

1. M. Khan, S. Pelengaris, ***The Molecular Biology of Cancer*,** First Edition, Wiley-Blackwell, 2006.

Supplementary Reading:

1. L. Pecorino, ***Molecular Biology of Cancer: Mechanisms, Targets and Therapeutics,*** 2nd edition, Oxford University Press, USA, 2008.

BM 443	INTRODUCTION TO BIOTECHNOLOGY	3 credits [3-0-0]

Prerequisites: NIL

Scope and importance of Biotechnology; Structure of prokaryoteandeukaryotic cells; Cell cycle and its regulation; analytical techniques for quantification of Biomolecules; Fine structure of gene; DNA replication damage andrepair; Regulation of gene expression; sequencing of DNA and proteins; Principles and applications of Recombinant DNA technology; Techniques for gene transfer in plants and production of transgenic plants; fusion and culture methods; Biotechnology; transgenic plants to combat biotic and abiotic stresses; Bioinformantics and its potential inplant and animal molecular biology; Animal cell culture; Biology of stem cell culture and its therapeutic applications; Current status of biotechnology researchin India.

Essential Reading:

1. W. J. Thiemanand M. A. Palladino, ***Introduction to Biotechnology,*** Benjamin Cummings; 2ndedition; 2008; ISBN-13**:** 978-0321491459.

SupplementaryReading:

1. M. Wink, ***an Introduction to Molecular Biotechnology: Molecular Fundamentals***, ***Methods and Applications in Modern Biotechnology,*** Wiley-VCH, 1st Edition, 2006, ISBN-13: 978-3527314126.

BM444	STRUCTURAL BIOLOGY	3 credits [3-0-0]

Prerequisites: NIL

Levels of structures in Biological macromolecules, Forces that determine Protein and Nucleic acid structure. Polypeptide chains; hydrogen bonding, hydrophobic interactions and water structures; ionic interactions, disulphide bonds. Types of proteins and interactions that govern protein folding, protein structure, The protein globule and hydrophic interactions organized folds, folding mechanisms, membrane proteins, helix-coil transitions, Molecular recognition, supramolecular interactions, Functional importance of Protein-protein and protein-nucleic acid interactions. Prediction of protein structure; Nucleic acids; general characteristics of nucleic acid structure, geometric, glycosidic bond rotational isomers backbone rotational isomers and ribose puckering forces stabilizing ordered forms, base pairing, base stacking; tertiary structure of nucleic acids. Biochemical Kinetics studies, catalytic efficiency relaxation spectrometry, ribonuclease as an example. Size and shape of micro molecules: chromophores, transition dipole moments, absorbance, and concentration. Circular dichroism: Principle and applications; Diffusion ultra centrifugation viscometry; X-ray crystallography, NMR spectroscopy.

Essential Reading:

1. D. L. Nelson and M. M. Cox, ***Lehninger Principles of Biochemistry***, W. H. Freeman, Fourth Edition, 2004.
2. K. EvanHolde, C. Johnson and P. S. Ho**,** ***Principles of Physical Biochemistry,*** Prentice Hall, Second Edition, 2005.

Supplementary Reading:

1. P R. Bergethon**,** ***The Physical Basis of Biochemistry, The Foundations of Molecular Biophysics***, Springer, Corrected Edition, 2000.

BM 452	FERMENTATION TECHNOLOGY	3 credits [3-0-0]

Prerequisites: NIL

Introduction to fermentation: Rate of microbial growth and death. Fermentation kinetics, mass transfer diffusion, membrane transport, dialysis, nutrient uptake. Fermenter design, operation, measurement and control in fermentation. Aeration and agitation in fermentation: Oxygen requirement, measurement of adsorption coefficients, bubble aeration, mechanical agitation, correlation between mass-transfer coefficient and operating variables. Fermenor design, operation measurement and control and types of fermentation sub-merged/solid state. Sterilization-air sterilization, media sterilization. Batch/continuous fermentation, scale up in fermentation. Product recovery. Biological waste treatment and inplant sanitation. Principle and use of biosensor. Production of vitamins, amino acids, organic acids, enzymes and antibiotics, alcohols.

Essential Reading:

1. P. P. Stanburry and A. Whitaker, ***Principles of Fermentation Technology***. Pergamon Press, Oxford UK, 1984.

Supplementary Reading:

1. K. H. Steinkraus, ***Handbook of Indigenous Fermented Foods,*** MarcelDekker, 1983.

BM463	**FOODTECHNOLOGY**	**3 credits [3-0-0]**

Prerequisites: NIL

Food chemistry, Food analysis, Food biochemistry, Food biotechnology, Food microbiology, Numerical procedures, Food physics, Food processing, Food preservation, Food engineering, Food packaging, Nutrition, Sensory evaluation, Statistical analysis, Quality assurance and legislation, Toxicology, Product technology, Food packaging.

Essential readings:

1. Campbell, ***Food Technology,*** Heinemann Educational, 2002.
2. Ian Graham, ***Food Technology***, Smart Apple Media, 2008.

Supplementary readings:

1. Eiri Board, ***Technology of Food Preservation & Processing,*** Engineers India Research Institute, 2008.
2. Eiri Board, ***Technology of Food Processing Industries,*** Engineers India Research Institute, 2011.

BM 465	**BIOLOGICAL WASTE TREATMENT**	**3 credits [3-0-0]**

Prerequisites: NIL

Introduction, Types and characterization of biomedical waste, hazards of Standards of BMW; Health BMW and its assessment, medical waste handling methods, treatment methods, : incineration, steam and gas sterilization, chemical, thermal, irradiation & microwave treatments, grinding a & shredding, compaction; Management of infectious waste; Medical waste reuse, recycling and reduction; Control and monitoring of airpollution caused by BMW; Casestudies on BMW management in hospitals and medical colleges; Recent advances in BMW; Regulation/legal provision on BMW.

Essential Reading:

1. V. J. Landrum, ***Medical Waste Management and Disposal***, William Andrew Inc, 1999
2. R. Radhakrishan, ***Biomedical Waste Management***, Sumit Enterprises, 2007

SupplementaryReading:

1. J. Kishore, G. K. Ingle, ***Biomedical Waste Management in India***, 1st ed, Century Publications NewDelhi, 2004.
2. Jr. W. C. Blackman, ***Basic Hazardous Waste Management***, Third Edition, 2001

BM 471	**BIOPROCESS DESIGN LABORATORY**	**2 credits [0-0-3]**

Prerequisites: NIL

Introduction, Process Development, process alternatives, Process flowsheeting and simulation using ASPEN PLUS, Conceptual Process Synthesis, Conceptual design of reactors, Bioreactor design, Bioreactor Design parameters, pressure vessels, distillation/adsorption columns, storage vessels, Synthesis of Separation Trains, Cost Estimation & profitability analysis, Scale-up & pilot plant studies, Safety in design, Batch process Design for sequential processing using, Continuous Bioreactor design (group term projects).

BM 472	**BIOMICROFLUIDICS LABORATORY**	**2 credits [0-0-3]**

Prerequisites: NIL

Introduction to Microfluidics System design module (Comsol based), Simulation of two fluid mixing in straight Y-channel, Mixing in Y-channel with serpentine section (Importance of Convection, Diffusion and Secondary Flows in Biological Sample Preparation), Simulation of electrokinetic flow in microfluidic devices (Biochip), H-Filter design and simulation for Cell Separation & Concentration Gradient Chemotaxis, Simulation of 3D Fluid-Structure Interaction in Microchannel

BM 473	FOOD TECHNOLOGY LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Enumeration of microorganisms, Isolation of lactic acid bacteria from yoghurt. To study the spreading coefficient of butter, stored at different temperatures., To determine the puncture strength of fruits and vegetables, To study the bloom strength of the gelatin gels. To determine the fracture strength of the chocolates using 3-point bending setup.; To study the extrusion properties of dough, To study the peeling strength of the packaged seals.; To study the cutting strength of fruits and vegetables. To determine the moisture content within food materials.; To study the viscosity of the commonly available sauces and ketchups.

BM 481	TISSUE ENGINEERING LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Module 1 - Scaffold Formation and Characterization; Preparation of 2D Collagen Films; Preparation of 3D Scaffolds; Preparation of Silk Fibroin scaffold by Salt Leaching Method; Preparation of Silk Fibroin scaffold by Phase Separation Method; Preparation of Silk Fibroin scaffold by Electrospinning; Design of 3D scaffold by rapid proto typing technique.; Characterization of biopolymers and scaffold; Mechanical Strength; Contact angle measurement; Pore size & Porosity; Module 2 - Cells and Cell Culture; Introduction to Cell Culture lab and aseptic skill; (Use of Biosafety cabinet, CO2 incubators, Microscopes, Sterile Conditions); Preparation of Cell Culture Media and other supplements & Additives; Isolation and Culturing of MNCs from Peripheral blood; Cell counting & cell morphology Module 3 - Bioreactors and Integration; Introduction to type of bioreactors & their operation; (Spinner Flask, Rotating vessel, Perfused Column and Perfused Chamber); MNC seeding on 2D films and 3D scaffolds; MNC seeding on 2D & 3D polymer scaffolds by static method; MNC seeding on 2D & 3D polymer scaffolds by dynamic method; Culture and cell growth study in bioreactor; Module-4 -Cell Survival & Function; Live/Dead Fluorescence Assay; MTT Viability Test; Cell Viability Test by Trypan Blue staining method

BM 482	COMPUTER AIDED TISSUE ENGINEERING LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Scaffold Based Tissue Engineering-: MIMICS – 1, Scaffold Design 1: CT/MRI Image-based 3D Reconstruction & Unit Cell Design-MIMICS – 2, CAD Modeling of tissue anatomy, Scaffold Design 2: Biomaterials- MIMICS – 3, Scaffold Design 3: Biomaterials-MIMICS-4, Scaffold Design 5: CAE analysis, Scaffold Fabrication 1: Chemical Techniques, CAE analysis of Scaffold Design, Scaffold Fabrication 2: Solid Freeform Techniques, Scaffold Fabrication 3: Cell Fabrication Techniques, Project Discussion & Assignments, Project Assignment, Project Presentation

BM 483	COMPUTATIONAL BIOMECHANICS LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Stresses analysis on hard tissues/ soft tissues in uniaxial, biaxial and tri axial loading, Stress analysis on femur during standing (axial, bending), Stress analysis on hip joint during motion (static and dynamic), Stress analysis on knee cap, Stress analysis on shoulder joint, Biomechanics of spine, Biomechanics of human jaw, Analysis of Foot forces during walking and jumping

BM 484	STRUCTURAL BIOLOGY LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Monitoring protein unfolding and refolding. Protein misfolding and aggregation in vitro. Study the thermodynamics of protein folding, misfolding. Monitoring Protein-DNA interaction. Study Protein, DNA and various metallic nanoparticle interactions. Study the folding behaviour of proteins by the action of Heat shock proteins (Hsp). Small ligand docking. Protein-protein docking. Protein-Protein, Protein-DNA interaction study by Chromatography. Protein-Protein interaction study by Isothermal titration calorimetry.; Calculation of Hydrophobicity and other surface characters of macromolecules by online software. Estimation secondary and tertiary structure of proteins by online software. Study Protein, DNA and various metallic nanoparticle interactions. Monitoring the process of amyloid formation of a protein in-vitro.

DEPARTMENT OF CIVIL ENGINEERING

DETAILED SYLLABI OF COURSES

Sub Code	Subject Name	L-T-P	Credits
CE 100	Engineering Mechanics	3-1-0	4
CE 130	Environment and Safety Engineering	3-1-0	4
CE 171	Engineering Drawing	0-0-3	2
CE 201	Civil Engineering Materials and Construction	3-0-0	3
CE 202	Surveying	3-0-0	3
CE 203	Mechanics of Solids	3-0-0	3
CE 204	Elements of Architecture & Town Planning	3-0-0	3
CE 205	Architecture & Town Planning	3-1-0	4
CE 207	Cost Effective Housing	3-1-0	4
CE 209	Concrete Technology	3-1-0	4
CE 212	Structural Analysis	3-0-0	3
CE 214	Theory of Elasticity	3-0-0	3
CE 252	Fluid Mechanics	3-1-0	4
CE 261	Elements of Civil Engineering	3-0-0	3
CE 271	Building Drawing Practice	0-0-3	2
CE 272	Highway Engineering Laboratory	0-0-3	2
CE 273	Mechanics of Solids Laboratory	0-0-3	2
CE 274	Surveying Field Work	0-0-3	2
CE 301	Advanced Surveying	3-1-0	4
CE 302	Disaster Management	3-0-0	3
CE 303	Remote Sensing and Geographic Information System	3-0-0	3
CE 311	Structural Design	3-0-0	3
CE 312	Design of Steel Structures	3-0-0	3
CE 313	Advanced Structural Analysis	3-1-0	4
CE 314	Structural Dynamics	3-1-0	4
CE 316	Advanced Mechanics of Solids	3-1-0	4
CE 318	Finite Element Method	3-1-0	4
CE 321	Mechanics of Soil	3-0-0	3
CE 322	Geotechnical Engineering	3-0-0	3
CE 331	Environmental Engineering	3-0-0	3
CE 333	Environmental Impact Assessment	3-1-0	4
CE 334	Air Quality Management	3-1-0	4
CE 336	Advanced Environmental Engineering	3-1-0	4
CE 341	Basic Transportation Engineering	3-0-0	3
CE 342	Transportation Engineering	3-0-0	3
CE 351	Hydraulics and Hydraulic Machines	3-1-0	4
CE 352	Advanced Fluid Mechanics	3-1-0	4
CE 371	Geotechnical Engineering Laboratory	0-0-3	2
CE 372	Steel Structures Design Practice	0-0-3	2

Sub Code	Subject Name	L-T-P	Credits
CE 373	Advanced Surveying Field work	0-0-3	2
CE 374	Transportation Engineering Design Practice	0-0-3	2
CE 375	Structural Engineering Design Practice	0-0-3	2
CE 376	Environmental Engineering Design Practice	0-0-3	2
CE 377	Fluid Mechanics and Hydraulic Machines Laboratory	0-0-3	2
CE 378	Environmental Engineering Laboratory	0-0-3	2
CE 391	Special Topic in Civil Engineering – I		3/4
CE 392	Special Topic in Civil Engineering – II		3/4
CE 393	Special Laboratory in Civil Engineering – I	0-0-3	2
CE 394	Special Laboratory in Civil Engineering – II	0-0-3	2
CE 395	Engineering Product Development Project – I	0-0-6	4
CE 396	Engineering Product Development Project – II	0-0-6	4
CE 401	Estimation, Costing & Construction Management	3-1-0	4
CE 403	Optimization Methods in Engineering	3-0-0	3
CE 404	Quality Management	3-0-0	3
CE 405	Disaster Management	3-0-0	3
CE 407	Optimization Methods and Its Applications in Civil Engineering	3-0-0	3
CE 411	Plate and Shell Structures	3-0-0	3
CE 412	Pre-stressed Concrete	3-0-0	3
CE 413	Advanced Design of Reinforced Concrete Structures	3-0-0	3
CE 415	Earthquake and Wind Resistant Design of Structures	3-0-0	3
CE 418	Probability and Reliability Methods in Civil Engineering	3-0-0	3
CE 421	Ground Improvement Techniques	3-0-0	3
CE 423	Advanced Foundation Engineering	3-0-0	3
CE 424	Earthquake Geotechnical Engineering	3-0-0	3
CE 425	Environmental Geotechnics	3-0-0	3
CE 426	Soil Structure Interaction	3-0-0	3
CE 428	Soil Dynamics and Industrial Foundations	3-0-0	3
CE 432	Environmental Biotechnology	3-0-0	3
CE 436	Environmental Management in Industries	3-0-0	3
CE 441	Advanced Transportation Engineering	3-0-0	3
CE 442	Traffic Engineering & Transportation Planning	3-0-0	3
CE 443	Pavement Design	3-0-0	3
CE 444	Pavement Materials	3-0-0	3
CE 445	Design of Airports and Hill Roads	3-0-0	3
CE 451	Irrigation Engineering	3-0-0	3
CE 452	Water Resources Engineering	3-0-0	3
CE 453	Computational Fluid Dynamics	3-0-0	3
CE 454	Ground Water Hydrology	3-0-0	3
CE 455	Open Channel Flow	3-0-0	3
CE 456	Water Resources Planning and Management	3-0-0	3

Sub Code	Subject Name	L-T-P	Credits
CE 471	Computer Aided Design Practice	0-0-3	2
CE 472	Structural Engineering Laboratory	0-0-3	2
CE 473	Geotechnical Engineering Design Practice	0-0-3	2
CE 474	Water Resources Engineering Design Practice	0-0-3	2

Note: For 6 level courses please refer to M. Tech Curriculum and Syllabi.

CE 100 ENGINEERING MECHANICS 4 Credits [3-1-0]

Statics: Introduction: Basic Concepts of Force, Moment and Couple; System of Coplanar forces, Equilibrium of Coplanar force systems, Free body diagrams and method of solution of engineering problems, Friction, Coulomb's Laws for dry friction, Coefficient of friction, Angle of friction, Belt friction and Screw Jack; Internal forces in Members of Trusses and Frames (Method of joints, Method of Sections) and Method of Members; Centroid: Theorems of Pappus, Moment of Inertia of plane figures, Polar Moment of Inertia and Product of Inertia; Principle of Virtual Work and application; Dynamics: Kinetics of Rectilinear motion and Curvilinear motion of a particle - D'Alembert's Principle, Linear Momentum and Impulse, Moment of Momentum, Work and Energy, Impact; Rigid Body motion - Kinematics of rotation and plane motion, Instantaneous Centre of Rotation; Equation of motion of a Rotating rigid body, D'Alembert's Principle for rotation and plane motion, Resultant Inertia force in Rotation, Compound Pendulum, Angular Momentum, Energy Equations for rotating bodies, Equations of Plane Motion of a rigid body and Energy equations for Plane motion.

Essential Reading:

1. S. P. Timoshenko, D. H. Young, and J. V. Rao: ***Engineering Mechanics,*** revised fourth edition, Tata-McGraw Hill, Special Indian Edition, 2007.
2. R. C. Hibbeler, ***Engineering Mechanics (Statics and Dynamics)***, Pearson Education Asia Pvt. Ltd, 2000.

Supplementary Reading:

1. A. K. Tayal, ***Engineering Mechanics***, Umesh Publications, Delhi, 11th edition, 2001.
2. F. P. Beer and E. R. Johnston, ***Mechanics for Engineers (Static & Dynamics)***, 7th edition, McGraw Hill International Student Edition, 2003
3. J. L. Meriam and L. G. Kraige, ***Engineering Mechanics (Static & Dynamics)***, John Wiley, 2002.

CE 130 ENVIRONMENT AND SAFETY ENGINEERING 4 Credits [3-1-0]

Environmental Engineering: Introduction to Environmental engineering Nature and scope of environment problems; Ecosystem effects through bio-geochemical cycles; Local, regional and global environmental challenges, Basic concepts of biodiversity and its significance, human behavior and values for a sustainable society; Water Pollution Fundamentals and Control Strategies: Water quality-physical, chemical & biological characteristics, Drinking water standards; Effluent quality requirements; Water and wastewater treatment processes-treatment train, physical, chemical and biological unit operations; Air Pollution Fundamentals and Control Strategies: Air pollution - sources, classifications and regulations; indoor air pollution, air pollutants and their effects, Monitoring Principles and instrumentation for particulate and gaseous pollutant measurements; Air pollution control strategies: physical, chemical and biological methods; Noise standards and criteria, Noise pollution measurement in ambient air and industrial complex, Control methods for noise pollution; Engineering principles in waste management, Case studies on industrial applications of cleaner technologies in chemical, metallurgical, pulp and paper, textile, electroplating, leather, dairy, cement and other industries. Environment Management and Sustainability Tools for sustainable management including ISO certification, environment audit, EIA and LCA; National and International policies, regulations and institutions.; **Safety Engineering:** Introduction: Background, Benefits of safety in Industry, Safety Terms and Definitions. Safety Mathematics and Reliability Basics: Basic Statistics, Set Algebra, Probability, Reliability. Workplace Accidents and Safety: Accident Causation Theories (Dmino Theory, Human Factor Theory), Accident Investigation and Reporting. Legal Aspects of Safety: Factories Act 1948, Other International Codes (OSHA Laws & Regulations). Hazards Related to Various Industries: Chemical, Electrical, Mining, and Construction Safety and Risk Management: Safety Management Principles, Safety Program Plan, Safety Committees, Safety Performance Measures, Risk Assessment, Risk Management. Safety Analysis Methods: FMEA, FTA, Markov Method, HAZOP, JHA, Control Charts. Human Factors in Safety: Job Stress, Ergonomics, Human behaviour, Human Reliability Prediction Models, Personal Protective Equipments; Safety Costing; Safety Cost Estimation Methods, Safety Cost Estimation Models, Safety Cost Performance Measurement Indices.

Essential Reading:
1. M. L. Davis and D. A Cornwell, ***Introduction to Environmental Engineering***, McGraw Hill International, 2005
2. B. S. Dhillon, ***Engineering Safety: Fundamentals, Techniques, Applications***, World Scientific.

Supplementary Reading:
1. G. Kiely, ***Environmental Engineering***, McGraw Hill Int. 2004

CE 171	ENGINEERING DRAWING	2 Credits [0-0-3]

Introduction to AutoCAD basic commands, Code provision of IS-696 regarding Lines, Lettering and Dimensioning. Drawing of Scales (Plane Scales, Diagonal Scales, Vernier Scales and Scales of Chords), Construction of simple geometrical figures and Engineering curves; Orthographic Projections: Projection of a point situated in various quadrants, projections of straight lines, true length, true inclinations and traces of a straight lines, auxiliary projections, auxiliary inclined and Auxiliary vertical planes, projection of plane figures. Projection of simple solids, Auxiliary projection of solids, section of solids, true shape of section; Development of surfaces: prisms, pyramids, cylinders, cones, spheres, pipe bends; Isometric projection: Principles, Isometric scales, Isometric projection of plane figures and simple solids.

Essential Reading:
1. K. Venugopal, ***Engineering Drawing and Graphics + AutoCAD***, New Age International (P) Limited. 4th Reprint: June, 2008.
2. N. D. Bhatt, ***Geometrical Drawing***, Charotar Book Stall, 2002.

Supplementary Reading:
1. K. L. Narayana and P. Kannaiah, ***Engineering Graphics***, Tata McGraw Hill Publishing Co. Ltd.
2. J. D. Bethune, ***Engineering Graphics with AutoCAD***, Pearson Education.

CE 201	CIVIL ENGINEERING MATERIALS AND CONSTRUCTION	3 Credits [3-0-0]

Materials: Stone-classification, quarrying and dressing; Brick-manufacturing, testing, classification, special bricks, cement concrete, timber –seasoning, defects, bitumen; Special materials: Alternate timber material, polymer based building materials, geogrids, geosynthetic, ceramic products, cladding. Building construction: Foundation: - Spread footing, isolated, combined and cantilever footing, raft foundation. Pile foundation; Stone and Brick Masonry: Comparison, general principles, bonds and joints. Reinforced concrete and reinforced brick work; Damp proofing of floors and walls; Doors and Windows: Definition, function and classification, Principles governing their number, size, area and positioning; Staircase and escalators

Essential Reading:
1. B. C. Punmia, ***Building Construction***, Laxmi Publication.
2. P. C. Varghese, ***Building Materials***, Prentice Hall of India, New Delhi-1.

Supplementary Reading:
1. D. S. Arora, ***Text book of Engineering materials***, Kalyani publication.
2. D. N. Ghose, ***Material of Construction***, Tata McGraw Hill.
3. S. K. Duggal, ***Building Materials***, New Age International Pvt. Ltd.

CE 202	SURVEYING	3 Credits [3-0-0]

Introduction: classification of surveys; Linear measurements: Types of Chains and tapes, chaining and ranging, principles of chain survey, equipments, applications, errors and corrections, obstacles in chaining, - Electronic Distance Measurement (EDM); Angle and direction measurements: Measurement of bearing, Computation of angles from - Bearings, Designation of bearings, fore bearing and back bearing, Prismatic compass, Principles of compass survey, local attraction and corrections, compass traverse and adjustments; Plane table survey: Equipments, working operations, different methods, advantages and disadvantages, Two point and Three point problems; Levelling: Principle, Levelling instruments, Dumpy level, booking and reducing levels, simple and differential levelling, profile and reciprocal levelling, methods of levelling, curvature and refraction corrections, bubble tube and its sensitiveness, levelling difficulties. Contouring: definition, contour interval, characteristics of contours, direct and indirect methods of contouring, interpolation of contours, uses of contour maps; Minor instruments: box sexant, planimeter, pentagraph, inclinometer

Essential Reading:
1. S. K. Roy, ***Fundamentals of Surveying***, PHI.
2. B. C. Punmia, A. K. Jain & A. K. Jain, ***Surveying Vol-I, Vol-II***, Laxmi publications.

Supplementary Reading:

1. T. P. Kanetkar & Kulkarni, ***A text book of Surveying and Levelling***.
2. D. Clark, ***Plane and Geodetic Surveying***, Constable Company Ltd, 10 Orange Street, London WC.

CE 203 MECHANICS OF SOLIDS 3 Credits [3-0-0]

Concept of Stress and strain, Definition of stress, stress tensor, normal and shearing stresses in axially loaded members, stress-strain relationship; Generalized Hooke's Law, Poisson's ratio, relationship between E, G, K and ν, stress-strain diagram for uniaxial loading, working stress.; Analysis of Axially Loaded Members, Composite bars in tension and Compression, temperature stresses in composite rods, statically indeterminate problems, Transformation of Plane stress and Plane strain, principal stresses and principal planes, Mohr's circle of stress, principal strains and principal axes of strain, Mohr's circle for strain, Strain rosettes, determination of principal strains from strain measurements, calculation of principal stresses from principal strains; Stresses in thin cylinders and thin spherical shells, wire winding of thin cylinders; Torsion of Circular shafts and Helical Springs, strength of solid and hollow circular shafts, design of circular members in torsion, close coiled helical springs; Members subjected to flexural loads, shear force and bending moment diagrams for cantilever and simply supported beams, elastic curve.; Theory of simple bending, bending stresses in beams, shearing stresses in beams, composite beams, Slope and deflection of beams by integration method and moment area method; Euler's theory for compression members; short struts with eccentric loading, Kern of rectangular and circular sections.

Essential Reading:

1. E. P. Popov, ***Engineering Mechanics of Solids***, Prentice hall of India Pvt. Ltd.
2. S. P. Timoshenko and D. H. Young, ***Elements of Strength of Materials***, Affiliated East West Press Pvt. Ltd.

Supplementary Reading:

1. G. H. Ryder, ***Strength of Materials***, ELBS.
2. H. Shames, ***Introduction to Solid Mechanics***, Prentice hall of India Pvt. Ltd.

CE 204 ELEMENTS OF ARCHITECTURE AND TOWN PLANNING 3 Credits [3-0-0]

Architectural development: historic examples, factors influence architectural development; Principles of architectural design: primary elements, form, space, organization, circulation, proportion and scale, ordering principles; Functional planning of buildings: Planning, designing and construction, general building requirements, (as per the National building Code); Evolution of towns: origin and growth, historical development of town planning in ancient valley civilizations; Objects and necessary of town planning; Surveys and analysis of a town; New Concepts in town planning: Garden city movement, Linear city and Satellite city concepts, Neighborhood Planning; Planning Principles, Practice and Techniques: Elements of City plan, Estimating future needs, Planning standards, Estimating future needs, Zoning - its definition, height and bulk zoning, F. A. R.; Concepts of Urban planning, Design and Landscaping.

Essential Reading:

1. B. Gallion and S. Eisner, ***The Urban Pattern: City planning and Design*** - C B S publishers, 5th edition, 2005.
2. D. K. Francis Ching, ***Architectures: Form, Space and Order,*** John Wiley, 2nd edition 1996.

Supplementary Reading:

1. ***National Building Code of India 2005***, BIS, New Delhi.
2. S. Eisner, A. B. Gallion and S. Eisner, ***The Urban Pattern: City planning and Design***, John Wiley 6th edition 1996.

CE 205 ARCHITECTURE AND TOWN PLANNING 4 Credits [3-1-0]

Architectural development: natural and built environment, historic examples, factors influence architectural development; Principles of architectural design: design methods, primary elements, form, space, organization, circulation, proportion and scale, ordering principles; Functional planning of buildings: Planning, designing and construction, general building requirements, permit and inspection (as per the National building Code); Evolution of towns: history and trends in town planning: origin and growth, historical development of town planning in ancient valley civilizations; Objects and necessary of town planning; Surveys and analysis of a town; New Concepts in town planning: Garden city movement, Linear city and Satellite city concepts, Neighborhood Planning; Planning Principles, Practice and Techniques: Elements of City plan, Estimating future needs, Planning standards, Zoning - its definition, procedure and districts, height and bulk zoning, F. A. R., Master Plan; Concepts of Urban planning, Design and Landscaping.

Essential Reading:

1. B. Gallion and S. Eisner, ***The Urban Pattern: City planning and Design*** - C B S publishers, 5th edition, 2005.

2. D. K. Francis Ching, ***Architectures: Form, Space and Order,*** John Wiley, 2nd edition 1996.

Supplementary Reading:

1. ***National Building Code of India 2005***, BIS, New Delhi.
2. S. Eisner, A. B. Gallion and S. Eisner, ***The Urban Pattern: City planning and Design***, John Wiley 6th edition 1996.

CE 207 COST EFFECTIVE HOUSING 4 Credits [3-1-0]

Income based classification of population. High, Middle, Low Income group and economically weaker section. Basic shelter issues in India. Mindset of low income group and economically weaker section people. Problems associated with this group with relation to land, living condition and dwelling standards; Recommendation of housing and urban development corporation.; Traditional materials and techniques (rammed earth, sun dried bricks, wood, bamboo, jute); Alternate and developed methods / materials of construction: pressed soil blocks, use of stabilized soil, soil cement blocks, fly ash brick, by-product gypsum, foundation, arch foundation, walling- rat trap bond, roofing-filler slabs. Precast blocks and their use. Laurie Baker's experiments in low cost housing.; Modular constructions. Experimental observations/findings of CBRI. Use of cost effective technologies (CECT) in building constructions, stub foundation, Rat trap bond (walls), brick arches (alternates to lintels) filler slab (roof). Use of Ferro cement.; Cost effective housing for natural disaster mitigation.

Essential Reading:

1. L. J. Goodman, R. P. Lama, R. Rajani, F. J. Burian, ***Low cost Housing Technology***, Pergamon Press, 1979.
2. International Association for Earthquake Engg., ***Guidelines for Earthquake Resistant Non-Engineered Construction.***

Supplementary Reading:

1. L. Baker, ***Are slums inevitable?, Centre of science & technology for Rural Development***, (COSTFORD) Ayanthple, Thrissur, Kerala.
2. L. Baker, ***Houses- How to reduce the building cost***, ***Centre of science & technology for Rural Development***, COSTFORD Ayanthple, Thrissur-68003, Kerala.

CE 209 CONCRETE TECHNOLOGY 4 Credits [3-1-0]

Concrete: Constituent materials; Properties of Cements, aggregates, water, admixtures (chemical and mineral). Mineral admixtures- Silica fumes, fly ash, slag. Mix Design of Concrete; Properties of Fresh concrete- workability, compaction, curing, Hardened concrete- Compressive strength, split tensile strength, flexural strength; Elasticity, shrinkage and creep.; Durability of concrete, permeability; corrosion.; Special concrete- high strength concrete, high performance concrete, self compacting concrete, ready mix concrete; Form work for concrete; Concrete under special conditions- Corrosion resistant concrete, lightweight concrete, high density concrete, Concrete for seismic resistant structure,; Precast concrete blocks; Nondestructive testing methods- Ultrasonic pulse velocity, rebound hammer; Repair and Rehabilitation of concrete; fibre reinforced concrete, polymer modified concrete.

Essential Reading:

1. A. M. Neville, J. J. Brooks, ***Concrete Technology***, Low Priced Edition, Pearson Education, 2004.
2. A. R. Santhakumar, ***Concrete Technology***, Oxford University Press, 2007.

Supplementary Reading:

1. M. S. Shetty, ***Concrete technology- Theory & Practice***, S. Chand & Company New Delhi, 2005.
2. M. L. Gambhir, ***Concrete Technology***, Tata McGraw Hill Publishing Company Ltd., 1995.

CE 212 STRUCTURAL ANALYSIS 3 Credits [3-0-0]

Concept of determinate and indeterminate structures, determination of degree of indeterminacy in plane frame and continuous structures, determination of member forces in statically determinate pin-jointed space frames, deflection of pin-jointed plane trusses by Williot Mohr diagram; Rolling loads and influence line diagrams for simply supported beams, influence line for forces in members of Pratt and Warren trusses with parallel top and bottom chords; Analysis of fixed and continuous beams by Moment-Area method, Conjugate beam method and theorem of three moments, Analysis of three-hinged and two-hinged arches, Spandrel braced arches.; Analysis of suspension cable bridges with three-hinged and two-hinged stiffening girders subjected to dead and live loads, influence line for horizontal thrust, bending moment, normal thrust and radial shear for arches and suspension bridges.

Essential Reading:

1. R. C. Hibbler, ***Structural Analysis***, LCE, Pearson Education, New Delhi, 2007.
2. C. K. Wang, ***Intermediate structural analysis***, McGraw-Hill.

Supplementary Reading:

1. L. S. Negi, ***Theory and Problems in Structural Analysis***, Tata-McGraw Hill.
2. J. S. Kinney, ***Indeterminate Structural Analysis***, Narosa Publishing House, 1991.

CE 214	THEORY OF ELASTICITY	3 Credits [3-0-0]

Elementary Concept of Elasticity: Stresses in three dimensional bodies, equations of equilibrium, strain displacement relations, stress strain relations, compatibility equations, boundary conditions, plane stress, governing differential equation, Airy stress function(Cartesian co-ordinates). Theories of Failure: Theories of Failure and its graphical representation for two-dimensional cases. Thick walled cylinders: Thick cylinders subjected to internal and external fluid pressures, compound cylinders, shrink-fit. Energy Methods: Strain energy expression in three dimensions, strain energy due to axial load, bending and torsion, Castigliano's theorems, Principle of virtual work, Unit load and unit couple method. Unsymmetrical bending: Properties of beam cross- sections, slope of neutral axis, stresses and deflections in unsymmetrical bending. Shear centre of thin wall beam cross section. Curved beams: Bending of beams of large initial curvature, stress distribution in beams with rectangular, circular and trapezoidal cross sections, location of neutral axis, stresses in crane hooks, rings and chain links. Membrane stresses in shells, application to cylindrical, spherical and conical shells. Plastic Analysis of Beams: Plastic Modulus, Shape factor, plastic hinge, application to beams, and determination of collapse loads. Special Topics: Repeated stresses in structural and machine components, fatigue in metals, endurance limit, concept of stress concentration, stress concentration factor and notch sensitivity.

Essential Reading:

1. L. S. Srinath, ***Advanced Mechanics of Solids,*** Tata-McGraw Hill Publishing Co. Ltd., New Delhi.
2. S. P. Timoshenko, ***Strength of Materials, Part I and II***, D. Van Nostrand Company Inc.

Supplementary Reading:

1. A. P. Boresi, R. J. Schmidth and O. M. Sidebottom, ***Advanced Mechanics of Materials***, John Wiley and Sons.
2. F. B. Seely and J. O. Smith, ***Advanced Mechanics of Materials***, John Wiley and Sons.
3. J. S. Kinney, ***Indeterminate Structural Analysis***, Narosa Publications.
4. S. P. Timoshenko & J. N. Goodier, ***Theories of Elasticity***, McGraw Hill Publisher

CE 252	FLUID MECHANICS	4 Credits [3-1-0]

Physical properties of fluids- Compressibility, Elasticity, and Viscosity, Ideal and Real fluids, Concepts of shear stress, Newtonian and Non-Newtonian fluids.; Pressure-density-height relationships, Pressure on plane and curved surfaces, Buoyancy, Stability of immersed and floating bodies, Free and forced vortex; Steady and unsteady, Uniform and non-uniform, Laminar and Turbulent flows, Free surface flows and Enclosed flows,; Definition of one, two and three-dimensional flows, Velocity and Accelerations, Stream lines, Streak lines and Path lines, Stream tubes, Stream function and Velocity potential, flows nets, Circulation and Vorticity. Equation of continuity, One-dimensional Euler's equation of motion and its integration to obtain Bernoulli's equation, Momentum equation; Hydraulic mean radius, Concept of friction loss, Darcy-Weisbach equation Minor losses in pipe, Branched pipes in parallel and series, Transmission of power, Water hammer in pipes, Laminar flow in pipes-Hazen-Poiseulli's equation, Turbulent flow in pipes, Velocity distribution in pipes, Moody's diagram; Boundary layer thickness, Energy thickness, Laminar and turbulent boundary layer, separation of Boundary Layer. Momentum integral equation; Drag and Lift coefficient, Pressure drag and Friction drag characteristics on Sphere, Cylinder, and Disc, Circulation, Lift and Magnus effect, Lift Characteristics of air foils, Induced drag; Open channel flow, Uniform flow, Chezy's, Kutter's and Manning's equation, Concept of specific energy, Critical flow, Point gauge, Pitot tube, Current meter, Venturi meter, Orifice meter, Orifices and Mouth pieces, Notches and Weirs.

Essential Reading:

1. K. C. Patra, ***Engineering Fluid Mechanics & Hydraulic Machines***, Narosa Publishing House, New Delhi, I st edition, 2008.
2. P. N. Modi and S. M. Seth, ***Hydraulic and Fluid Mechanics***, Standard Book House, New Delhi, 2002.

Supplementary Reading:

1. J. F. Douglas, J. M. Gasiorek, J. A. Swaffield, ***Fluid Mechanics***, Pearson Education, Asia, 1st edition, 2002.
2. F. M. White, ***Fluid Mechanics***, Tata McGraw-Hill, 5th Edition, New Delhi, 2003.
3. R. K. Bansal, ***Fluid Mechanics and Hyd. Machines***, Laxmi publisher, New Delhi, 2008.
4. Som & Biswas, ***Fluid Mechanics and Fluid Machines***, Tata McGraw Hill, New Delhi, 2004.
5. Subramanyam, ***Problems in Fluid Mechanics***, Tata McGraw Hill, New Delhi, 2004.

CE 261	ELEMENTS OF CIVIL ENGINEERING	3 Credits [3-0-0]

Building materials and construction materials: Bricks, Stones, Cement, Cement mortar, Cement Concrete, Reinforced concrete, pre stressed concrete; Construction: Foundations, Brick masonry, Stone masonry, walls, columns, floors, steps & stairs, lintels, roofs, doors & windows; Surveying: Chain Surveying, Compass surveying, Plane Table Surveying, Leveling. Transportation Engineering: Classification of highways, principles of alignment, Types of pavements, geometric design of airport components; Floods: River systems and Flood forecasting.

Essential Reading:

1. M. S. Palanichamy, ***Basic Civil Engineering***, Tata McGrawhill 3rd Edition, 2000.
2. S. K. Khanna & C E G Justo, ***Highway Engineering***, Nemchand Bros, Roorkee, 8th edition 2001, Reprinted 2003

Supplementary Reading:

1. S. K. Duggal, ***Building Materials***, New Age International Pvt. Ltd.
2. S. C. Rangawala, ***Building Construction***, Charotar Publishing House
3. S. P. Bindra, ***A Course in Highway Engg.,*** Dhanpat Rai Publication
4. K. C. Patra, ***Hydrology & Water Resources Engg.,*** Narosa Publishing House, New Delhi, 2nd Edition

CE 271	BUILDING DRAWING PRACTICE	2 Credits [0-0-3]

Basic concept, purpose, function and types of building (Residential, Industrial and Institutional); Principles of site selection, orientation of buildings and distribution of space; Line plan. Development of plan from a line plan; Details of Doors, windows, foundation and stair case etc.; A simple two-roomed official building, multi-storeyed residential building plan, front and sectional elevations. Building drawing project.

Essential Reading:

1. M. G. Shah, C. M. Kale and S. Y. Patki, ***Building drawing with an integrated approach to built environment***-2002-Tata McGraw-Hill Publication.
2. O. A. Wakita and R. M. Linde, ***Study guide for the professional practice of architectural working Drawings***, 2nd edition 1994, John Wiley.

Supplementary Reading:

1. W. L. Lalph, ***Architectural working Drawings***, 4th edition, Sept. 1999, John Wiley.
2. W. T. Goodban and Jr. J. Hayslett, ***Architectural drawing and planning***, McGraw-Hill Pub
3. F. Reekie, ***Reekie's Architectural Drawing***, Elsevier.

CE 272	HIGHWAY ENGINEERING LABORATORY	2 Credits [0-0-3]

Determination of aggregate crushing value.; Determination of Los Angeles abrasion value of aggregates; Determination of aggregate impact value; Determination of penetration value of bitumen; Determination of softening point value of bitumen; Determination of ductility value of bitumen; Determination of flash and fire point of bitumen; Determination of specific gravity of bitumen; Determination of fineness modulus of coarse aggregate; Determination of fineness modulus of fine aggregate; Determination of stripping value of aggregate; Determination of bulking of sand; Determination of workability of concrete by flow table; Determination of flakiness index and elongation index of coarse aggregate; Determination of specific gravity and water absorption of coarse aggregate; Aging of bituminous binders; Marshall method of mix design; Demonstration of advanced equipments for characterization of pavement materials.

Essential Reading:

1. Highway Engineering Laboratory Manual
2. Relevant I. S. Codes

CE 273	MECHANICS OF SOLIDS LABORATORY	2 Credits [0-0-3]

Close coiled helical spring; Beam deflection; Brinell Hardness Test; Rockwell Hardness Test; Torsion Test on mild steel specimen; Tension test on mild steel specimen; Fatigue Test and determination of endurance limit; Column test; Compression testing; Experiments on strain measurement; Plane stress and plane strain; Charpy Impact Test.

CE 274	SURVEYING FIELD WORK	2 Credits [0-0-3]

Chain Triangulation of a given area; Plotting the chain triangulation; Traversing a given area with Prismatic Compass; Plotting the compass traverse and graphical adjustment; Filling up with details with plane-table by i) radial and ii) intersection method; Solving two-point problem and three-point problem; Study of Dumpy level and Auto level; Differential leveling; Permanent adjustment of Dumpy level; Reciprocal leveling; Determination of sensitiveness of the bubble tube; Profile leveling; Longitudinal sectioning and cross sectioning –Contouring; Interpolation of contours and preparation of contour map of a given area.

CE 301 ADVANCED SURVEYING 4 Credits [3-1-0]

Use of transit theodolites: Observing horizontal and vertical angles, electronic theodolite. theodilite traversing- checks in traversing, precision and error, traverse computations, adjustment of closed traverse, elementary ideas of geodetic computation, EDM, Total station instrument, electronic measurements in surveying; Tacheometry: Different types of tacheometric measurements- fixed and movable hair tacheometres, tangential system, auto reduction tacheometers, Subtense bar; Triangulation: First order triangulation, selection of stations, inter-visibility of stations, satellite station, Base-line measuring apparatus and baseline measurement, base net; Survey adjustments: Theory of errors, probable error, principle of least squares, normal equations and correlations, level net; Aerial photogrammetry: Principles, computation of scale and distance between points, relief displacement, measurement of height of different objects, ground control, flight planning, Remote sensing: Introduction to microwave remote sensing and basic concepts, spectral reflectance of ground features, data acquisition and interpretation, applications of remote sensing for resources mapping, monitoring and management, Acquaintance of Global Positioning System and Geographic Information System.

Essential Reading:

1. S. K. Duggal, ***Surveying, Vol-I & II***, 2nd Edition, Tata Mc-Graw Hill, 2004.
2. S. K. Roy, ***Fundamentals of Surveying***, PHI.

Supplementary Reading:

1. A. M. Chandra, ***Plane Surveying***, New Age International Pvt. Ltd., 2nd Edition, 2008.
2. A. M. Chandra, ***Higher Surveying***, New Age International Pvt. Ltd., 2nd Edition, 2007.
3. I. Heywood, S. Cornelius and S. Carver, ***An Introduction To GIS,*** Person Education, 2nd Edition, 2004.
4. T. M. Lillisand and R. W. Kaifer, ***Remote Sensing & Image Interpretation***, John Wiley & Sons Inc. 6th Edition, 2007.

CE 302 DISASTER MANAGEMENT 3 Credits [3-0-0]

Cyclones: Formation, Cyclonic precipitation, anti-cyclones, Flood: Flood and its estimation, Flood warning, Flood protection measures. Earthquake: Causes of earthquake, plate tectonics, seismic zoning map, Characteristics of strong ground motions & attenuation, damage assessment, rehabilitation and retrofitting of structures. Environmental disaster: Impact assessment studies, computation and preparedness. Disaster management: Developing appropriate technology for disaster mitigation, Role of management teams, importance of awareness, alertness and preparedness camp.

Essential Reading:

1. K. C. Patra, ***Hydrology and Water Resources Engineering***, CRC Press, Florida, USA, 2nd Edition.
2. N. Sharma, ***Earthquake resistant building construction***, S. K. Kataria & Sons, New Delhi.

Supplementary Reading:

1. K. Subramanian, ***Engineering Hydrology***, Tata McGraw Hill, New Delhi.
2. V. P. Singh, ***Elementary Hydrology***, Prentice Hall of India.
3. P. C. Sinha, ***Disaster Mitigation, Preparedness, Recovery and Response***, SBS Publishers & Distributors Pvt. Ltd.
4. D. P. Coppola, ***Introduction to International Disaster Management***, Butterworth-Heinemann.
5. F. B. Friedman, ***Practical Guide to Environmental Management***, McGraw Hill.

CE 303 REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM 3 Credits [3-0-0]

Introduction to Remote Sensing system: data acquisition and processing, Applications, Multi concept in remote sensing. Physical Basis of Remote Sensing: EMR nature, definition, nomenclature and radiation laws; Interaction in atmosphere-nature, its effects in various Wave-length regions, atmospheric windows; Interaction at ground surface soils Geometric basis of interaction. Platform and Sensors: Terrestrial, aerial and space platforms, Orbital characteristics of space platforms, sun- and geo-synchronous; Sensor systems-radiometers, opto-mechanical and push broom sensor; resolution : spectral, spatial, radiometric and temporal; IFOV, FOV, GRE; geometric characteristics of scanners, V/H and S/N ratio; Data products from various air and spaceborne sensors-aerial photographs, LiDAR, Landsat, SPOT, IRS, ERS, IKONOS etc., Image Interpretation: elements of interpretation; digital image processing and interpretation; Field verification. Geographical Information systems: components of GIS-data acquisition, spatial and attribute data, pre-processing, storage and management; data structures raster and vector data; GIS analysis functions; Errors and corrections; data presentation and generation of thematic maps.

Essential Reading:

1. A. M. Chandra and S. K. Ghosh, ***Remote Sensing and GIS,*** Narosa Pub, 2007.
2. T. M. Lillisand, R. W. Kaifer and J. W. Chipman, ***Remote Sensing and Image Interpretation***; John Wiley and sons Inc, 6th Edition Nov 2007.

Supplementary Reading:

1. I. Heywood, S. Cornelius and S. Carver, ***An Introduction to GIS***; Pearson Education-2nd Ed, 2002.

CE 311 REINFORCED CONCRETEDESIGN 3 Credits [3-0-0]

Introduction; Basic Material Properties; Basic Design Concepts - Working Stress Method (WSM), Ultimate Load Method (ULM), Limit States Method (LSM); Behaviour in Flexure; Design of Beams and One-way Slabs for Flexure; Design for Shear; Design for Torsion; Design for Bond; Serviceability Limit States: Deflection and Cracking; Design of Two-way Slab Systems; Design of Staircases; Design of Compression Members; Design of Footings and Retaining Walls; Detailing and Construction Practices.

Essential Reading:

1. S. Unnikrishna Pillai & D. Menon, ***Reinforced Concrete Design*** (Third edition), Tata McGraw Hill, 2008
2. A. Nilson, D. Darwin, C. Dolan, ***Design of Concrete Structures*** (13th edition), Tata McGraw- Hill

Supplementary Reading:

1. A. K. Jain, ***Reinforced Concrete: Limit State design***, Nem Chand and Bros. 1999.
2. S. K. Mallik and A. P. Gupta, ***Reinforced Concrete Design***, Oxford and IBH 1999.
3. ***Code of practice for Plain And Reinforced Concrete*** IS 456-2000.
4. SP-16: ***Design Aids*** to IS 456-1978.

CE 312 DESIGN OF STEEL STRUCTURES 3 Credits [3-0-0]

Materials, Structures and Specifications, Riveted, Bolted & welded Connections, Design of Tension and Compression Members, Design of Beams, plate girders and gantry girders, Design of industrial buildings; Design of slab and gusseted base.

Essential Reading:

1. N. Subramanian, ***Design of Steel Structures***, Oxford University Press, 1st Edition, 2008.
2. P. Dayarathnam, ***Design of steel structures***, S Chand & Co Ltd, New Delhi, 2nd Edition, 1999.
3. ***Indian Standard Code IS 800***, 2007.

Supplementary Reading:

1. R. Chandra and V. Gehlot, ***Design of steel structures***, Scientific Publishers, India, 2005.
2. B. C. Punmia, A. K. Jain and A. K. Jain, ***Design of Steel structures***, Laxmi Publications, 2nd Edition, 2004.
3. L. S. Negi, ***Design of steel structures***, Tata McGraw Hill.
4. A. S. Arya & J. L. Ajmani, ***Design of Steel Structures***, Nemchand & Bros.

CE 313 ADVANCED STRUCTURAL ANALYSIS 4 Credits [3-1-0]

Development of generalized slope deflection equations and its applications to beams and plane frames. Moment distribution method and its applications to continuous beams and plane frames including sway and inclined members Analysis of beams and frames by Kani's method including sway conditions and double storied frames.; Analysis of fixed arches by energy approach and Elastic center method. Energy Theorems, the theorem of conservation of energy, the minimum potential energy theorem, Raleigh-Ritz method of analysis of beams, stable, neutral and unstable equilibriums.; Study of Influence line diagram of indeterminate structures by Muller Breslue Principle.; Basics of matrix method of Analysis, the flexibility and stiffness method of analysis of beams and frames.

Essential Reading:

1. J. S. Kinney, ***Indeterminate Structural Analysis***, Narosa Publishing House, New Delhi, 1991.
2. R. C. Hibbler, ***Structural Analysis***, LCE, Pearson Education, New Delhi, 2007.

Supplementary Reading:

1. C. K. Wang, ***Indeterminate Structural Analysis***, Mc Graw- Hill, Auckland.
2. S. F. Borg and J. J. Genareo, ***Advanced Structural analysis***, Van Nostrand Company, London.

CE 314	STRUCTURAL DYNAMICS	4 Credits [3-1-0]

Single degree of freedom system: Equation of motion, Damped and undamped free vibration, Response to harmonic, periodic, impulse load and general dynamic load, Duhamel's integral; Multi degrees of freedom system: Equation of motion, Free vibration analysis, Dynamic response and modal analysis; Free and Forced vibration of distributed mass system: Beam

Essential reading:

1. R. W. Clough and J. Penzien, ***Dynamics of structures***, McGraw-Hill Inc.
2. A. K. Chopra, ***Dynamics of Structures: Theory and Applications to Earthquake Engineering***, Prentice Hall of India.

Supplementary Reading:

1. S. P. Timoshenko and D. H. Young, ***Vibration Problem in Engineering***, D. Van -Nostrang Company. Inc. Affiliated East-West Press Pvt. Ltd., New Delhi.

CE 316	ADVANCED MECHANICS OF SOLIDS	4 Credits [3-1-0]

Elementary Concept of Elasticity: Stresses in three dimensional bodies, equations of equilibrium, strain displacement relations, stress strain relations, compatibility equations, boundary conditions, plane stress, governing differential equation, Airy stress function(Cartesian co-ordinates). Theories of Failure: Theories of Failure and its graphical representation for two-dimensional cases. Thick walled cylinders: Thick cylinders subjected to internal and external fluid pressures, compound cylinders, shrink-fit. Energy Methods: Strain energy expression in three dimensions, strain energy due to axial load, bending and torsion, Castigliano's theorems, Principle of virtual work, Unit load and unit couple method. Unsymmetrical bending: Properties of beam cross-sections slope of neutral axis, stresses and deflections in unsymmetrical bending. Shear centre of thin wall beam cross section. Curved beams: Bending of beams of large initial curvature, stress distribution in beams with rectangular, circular and trapezoidal cross sections, location of neutral axis, stresses in crane hooks, rings and chain links. Membrane stresses in shells, application to cylindrical, spherical and conical shells. Plastic Analysis of Beams: Plastic Modulus, Shape factor, plastic hinge, application to beams, and determination of collapse loads. Special Topics: Repeated stresses in structural and machine components, fatigue in metals, endurance limit, concept of stress concentration, stress concentration factor and notch sensitivity.

Essential Reading:

1. L. S. Srinath, ***Advanced Mechanics of Solids***, Tata-McGraw Hill Publishing Co. Ltd., New Delhi.
2. S. P. Timoshenko, ***Strength of Materials, Part I and II***, D. Van Nostrand Company Inc.

Supplementary Reading:

1. A. P. Boresi, R. J. Schmidth and O. M. Sidebottom, ***Advanced Mechanics of Materials***, John Wiley and Sons.
2. F. B. Seely and J. O. Smith, ***Advanced Mechanics of Materials***, John Wiley and Sons.
3. J. S. Kinney, ***Indeterminate Structural Analysis***, Narosa Publications.
4. S. P. Timoshenko and J. N. Goodier, ***Theories of Elasticity***, McGraw Hill Publisher

CE 318	FINITE ELEMENT METHOD	4 Credits [3-1-0]

Equations of Equilibrium, Strain displacement relations, Stress strain Relations, Plane stress and plane Strain problems, Basics of finite element method (FEM), different steps involved in FEM, Different approaches of FEM, Direct method, Energy approach, Weighted residual Method; Finite Element modeling of one and two dimensional problems. Isoparametric elements, four node, eight node elements. Numerical integration, order of integration; Bending of plates, rectangular elements, triangular elements and quadrilateral elements, Concept of 3D modeling.

Essential Reading:

1. R. D. Cook, ***Concepts and Applications of Finite Element Analysis***, John Wiley, New York, 2004.
2. O. C. Zienkiewicz and R. L. Taylor, ***Finite Element Method***, Butterworth Heinemann publication, 2000.

Supplementary Reading:

1. C. S. Krishnamoorty, ***Finite element methods***, Tata-McGraw Hill, Second Edition, New Delhi, 2002.
2. T. R. Chandupatla and A. D. Belegundu, ***Introduction to Finite Elements in Engineering***, Prentice Hall of India Pvt. Ltd., New Delhi, 5th Reprint, 1999.
3. J. N. Reddy, ***An introduction to Linear Finite Element Method***, Oxford University Press, Oxford, 2004.

CE 321	MECHANICS OF SOIL	3 Credits [3-0-0]

Soil Properties and Classification: Formation of soils and types, Soil as three phase system. Soil consistency, sensitivity and thixotropy. Classification of soil.; Soil Compaction: Principles, water content - dry unit weight relationships, optimum moisture content, maximum dry unit weight, factors affecting compaction. Effects of compaction on density, shear strength and permeability. Field compaction methods; Permeability: Soil - water systems - capillarity, flow, Darcy's law, permeability and tests for its determination, Permeability of stratified soils, estimation of permeability in the field piping, quicksand condition, seepage, flow nets, flow through dams, filters.; Shear Strength of Soil: Coulomb's law, Mohr's stress circle, strength envelop and failure conditions. Direct, Triaxial and Unconfined compression tests, Vane shear test, Effect of pore pressure; Soil Stabilization: Mechanical stabilizations Chemical stabilization- Lime stabilizations, cement and cement lime stabilization, bitumen stabilization. Use of Geosynthetics and other ground improvement techniques.

Essential Reading:

1. S. K. Gulhati and M. Datta, ***Geotechnical Engineering***, McGraw Hill Company.
2. B. M. Das, ***Principles of Geo-technical Engg***, Thomson Books.

Supplementary Reading:

1. V. N. S. Murthy, ***Principles of Soil Mechanics and Foundation Engg***, UBSPD.
2. I. H. Khan, ***A text book of Geo-technical Engg***, Prentice Hall India.
3. B. C. Punmia, ***A text Book of Geo-technical Engg***, Laxmi Publications.
4. G. Ranjan & A. S. R. Rao, ***Basic and Applied Soil Mechanics***, Wiley Eastern Ltd.

CE 322	**GEOTECHNICAL ENGINEERING**	**3 Credits[3-0-0]**

Stresses in Soils: Boussinesq's Equation: Vertical Stress distribution on horizontal and vertical planes, . Newmark's influence chart, Contact pressure distribution. Consolidation and Settlement Analysis: Equation of one dimensional consolidation. Coefficient of consolidation, coefficient of compression, compression index, pre-compression pressure. Overconsolidation, Consolidation Settlement analysis. Basics of three- dimensional consolidation, Sand drains. Floating mat foundation.; Bearing Capacity and Analysis of Foundations –Shallow foundation: Terzaghi's bearing capacity equation, factors influencing bearing capacity. Bearing capacity for square, rectangular and circular footings. Bearing capacity under eccentric load on layered soil. Bearing capacity based on in-situ tests.; Pile Foundation- Load carrying capacity of a pile (Static and dynamic formulae), Pile group, Settlement analysis of pile.; Earth Pressure, Retaining Structures and Sheet Pile Walls: Earth pressure Theories- Rankine Earth pressure theory, Coulomb's Earth pressure theory.; Sheet pile walls: Pressure against sheet pile walls, cantilever and anchored bulk heads (free earth support method). Pressure against wallings in large trenches.; Soil Investigation: Conventional and Geo-physical methods of soil investigation. Stability of Slopes: Stability of infinite slopes, stability of finite slopes,

Essential Reading:

1. B. M. Das, ***Principles of Geo-technical Engg***, Thomson Books.
2. G. Ranjan and A. S. R. Rao, ***Basic and Applied Soil Mechanics***, Wiley Eastern Ltd.

Supplementary Reading:

1. S. K. Gulhati and M. Datta, ***Geotechnical Engineering***, McGraw-Hill Companies.
2. V. N. S. Murthy, ***Principles of Soil Mechanics and Foundation Engg,*** UBSPD.
3. 3. B. C. Punmia, ***A text Book of Geo-technical Engg***, Laxmi Publisher

CE 331	**ENVIRONMENTAL ENGINEERING**	**3 Credits [3-0-0]**

General requirement for water supply, Quality and quantity of water, Domestic water quality standards; Sources of water and their yield, population forecast, Design period; Intakes, pumping and transportation of water; Physical, chemical and biological characteristics of water and their significance, water quality criteria, water borne diseases, Appurtenances of water treatment and distribution systems. DO and BOD demand in streams.; Essentials of wastewater engineering, Quantities of wastewater and storm water, wastewater characteristics; Water and wastewater plumbing systems, Waste water collection and conveyance systems, Design of sewerage systems, Pumping of waste water.; Air pollution and pollutants, air quality, ambient and atmospheric standards, Sampling and monitoring of air pollutants. Prediction of air pollution dispersion, air quality modeling; Solid and hazardous waste management- Generation, on-site storage, collection, separation, processing and disposal On-site storage methods, Collection systems-Vehicles, routing, route balancing and transfer stations, Processing methods, recovery and reuse of materials and energy, Disposal methods such as sanitary landfill, biological digestion & etc.

Essential Readings:

1. M. J. Hammer, ***Water and Wastewater Technology***, Prentice Hall, 6th edition, 2007.
2. H. S. Peavy, D. R. Rowe and G. Tchobanoglous, ***Environmental Engineering***, McGraw-Hill Publishing Co., 7th Rev Ed edition, 2000.

Suggested Readings:

1. Metcalf & Eddy Inc., George Tchobanoglous, Franklin, L., Burton, H. D. Stensel, ***Wastewater Engineering: Treatment and Reuse***, McGraw-Hill Higher Education; 4th edition, 2002.
2. T. J. McGhee, E. W. Steel, ***Water Supply and Sewerage***, McGraw-Hill College; 6th edition, 1991.
3. C. N. Sawyer, P. L. McCarty, G. F. Parkin, ***Chemistry for Environmental Engineering and Science***, McGraw-Hill Inc., 5th edition, 2002.
4. S. K. Friedlander, ***Smoke, Dust & Haze: Fundamentals of Aerosol Dynamics***, Oxford University Press, New York, 2nd edition, 2000.

CE 333 ENVIRONMENTAL IMPACT ASSESSMENT 4 Credits [3-1-0]

Evolution of EIA; EIA at project; Regional and policy levels; Strategic EIA; EIA process; Screening and scoping criteria; Rapid and comprehensive EIA; Specialized areas like environmental health impact assessment; Environmental risk analysis; Economic valuation methods; Cost-benefit analysis; Expert system and GIS applications; Uncertainties; Practical applications of EIA; EIA methodologies; Baseline data collection; Prediction and assessment of impacts on physical, biological and socio-economic environment; Environmental management plan; Post project monitoring, EIA report and EIS; Review process. Case studies on project, regional and sectoral EIA; Legislative and environmental clearance procedures in India and other countries, Siting criteria; CRZ; Public participation; Resettlement and rehabilitation.

Essential Reading:

1. B. M. Noble, ***Introduction to Environmental Impact Assessment: A Guide to Principles and Practice***. Oxford University Press, USA, 2005.
2. J. Glasson, ***Introduction to Environmental Impact Assesment: Principles, and Procedures, Process, Practice and Prospects (The Natural and Built Environment Series)***, Routledge; 3rd edition, 2005.

Supplementary Reading:

1. P. Morris, ***Methods of Environmental Impact Assessment (The Natural and Built Environment Series)***, Spon Press, USA, 2nd edition, 2001.
2. R. K. Jain, L. V. Urban, G. S., Stacey, Harold, E. Balbach, ***Environmental Assessment***, McGraw-Hill Professional; 2 edition, 2001.
3. B. B. Marriott, ***Environmental Impact Assessment: A Practical Guide***, McGraw-Hill Professional, 1 edition, 1997.
4. D. P. Lawrence, ***Environmental Impact Assessment: Practical Solutions to Recurrent Problems***, Wiley-Interscience; 1st edition, 2003.

CE 334 AIR QUALITY MANAGEMENT 4 Credits [3-1-0]

Air pollutants, Sources, classification, Combustion Processes and pollutant emission, Effects on Health, vegetation, materials and atmosphere, Reactions of pollutants in the atmosphere and their effects-Smoke, smog and ozone layer disturbance etc; Atmospheric diffusion of pollutants and their analysis, Transport, transformation and deposition of air contaminants on a global scale, Air sampling and pollution measurement methods, principles and instruments; Emission factors, regulations, control strategies and policies. Particulate Pollutant Control: Settling chambers - laminar and turbulent flow; Filtration - interception; Impaction; Convective diffusion; Collection of particles by cylindrical fibres and granular beds; Electrostatic precipitation - field and diffusion charging; Electrical migration velocity; Cyclones - laminar and turbulent flow; Wet collectors; Efficiency and dimensions of particle control devices. Gaseous Pollutant Control: Gas absorption in tray and packed towers; Stage efficiency; Liquid/gas rates; Equilibrium number of stages/ packed height; Absorption with/without chemical reaction; Removal of SO2; Adsorption in fixed beds; Breakthrough; Removal of HCs/VOCs; NOx removal from effluent streams; Wet scrubbers. Integrated air pollution control systems; Effect of process parameters on performance of control systems.

Essential Reading:

1. N. de Nevers, ***Air Pollution Control Engg***. McGraw-Hill Inc, 2000.
2. R. D. Griffin, ***Principles of Air Quality Management***, CRC, 2nd Edition, 2006.

Supplementary Reading:

1. R. W. Boubel, D. L. Fox, B. Turner, A. C. Stern, ***Fundamentals of Air Pollution***, Academic Press London/ Elsevier, 1994.
2. S. K Fiendlander, ***Smoke, Dust and Haze: Fundamentals of Aerosol Dynamics***, Oxford University Press, New York, 2000.
3. C. S. Rao, ***Environmental Pollution Control Engg***, Wiley Eastern Ltd, 1995.

CE 336 ADVANCED ENVIRONMENTAL ENGINEERING 4 Credits [3-1-0]

Engineered systems for water treatment: aeration, coagulation, flocculation, sedimentation, softening, filtration, adsorption, Ion exchange, and disinfection. Water distribution systems.; Primary and secondary treatment of wastewater; Wastewater disposal standards, Biological wastewater treatment systems: Aerobic processes - activated sludge process and its modifications, trickling filter, RBC, Anaerobic Processes - conventional anaerobic digester, High rate and hybrid anaerobic reactors.; Tertiary treatment of industrial wastewater including removal of nitrate, sulphate, phosphorous, pathogens, color, odor, TDS, COD and residual BOD; Sector specific issues in management of industrial wastewater including petrochemical, textile, food processing, pharmaceutical, fertilizer, pesticides etc.; Sludge digestion and handling. Disposal of effluents and sludge.; Policy and legislation including challenges posed by various sectors of industries and legislation framework and regulations in India; Case studies.

Essential Reading:

1. M. J. Hammer, ***Water and Wastewater Technology,*** Prentice Hall, 6th Edition, 2007.
2. H. S. Peavy, D. R. Rowe, ***George Tchobanoglous, Environmental Engineering***, McGraw-Hill Publishing Co.; 7th Rev Edition, 1987.

Supplementary Reading:

1. Metcalf & Eddy Inc., G. Tchobanoglous, L. F. Burton, H. D. Stensel, ***Wastewater Engineering: Treatment and Reuse***, McGraw-Hill Higher Education; 4th edition, 2002.
2. T. J. McGhee, E. W. Steel, ***Water Supply and Sewerage***, Mcgraw-Hill College; 6th Edition, 1991.
3. C. N. Sawyer, P. L. McCarty, G. F. Parkin, ***Chemistry for Environmental Engineering and Science***, McGraw-Hill Inc., 5th Edition, 2002.
4. S. K. Friedlander, ***Smoke, Dust and Haze: Fundamentals of Aerosol Dynamics***, Oxford University Press, New York, 2nd Edition, 2000.

CE 341 BASIC TRANSPORTATION ENGINEERING 3 Credits [3-0-0]

Highways: Introduction, Road Development plans and programmes; Principles of alignment; Geometric design: Cross-sectional elements, Camber and superelevation, Horizontal curve and extra widening, Gradient, Sight distance; Pavement materials: Aggregates and Bituminous binders; Bridges: Classification of bridges; Calculation of runoff under bridges; Determination of water way: Economic span; Bridge foundations, Piers and abutments, Superstructures; Temporary bridges and causeways; Railways: Introduction; Cross section and components of railway track; Problems of multi gauge system; wheel and axle arrangements, Coning of wheels; Geometric design: Horizontal curves, super elevation, equilibrium cant and cant deficiency, Gradients and grade compensation; Points and crossing; Airport; Aircraft characteristics; Typical layout and components; Runway- orientation and configuration, Basic runway length and corrections; Main and exit Taxiway; Apron and Terminal Building; Airport marking and lighting.

Essential Reading:

1. S. K. Khanna & C E G Justo, ***Highway Engineering, Nemchand Bros***, Roorkee, 8th edition 2001, Reprinted 2003
2. D. J. Victor, ***Essentials of Bridge Engineering,*** Oxford & IBH, 6th ed., 2007.
3. S. Chandra & M. M. Agarwal, ***Railway Engineering,*** Oxford University Press, New Delhi, 1st Ed. 2007.
4. S. K. Khanna & M. G. Arora, Airport planning and Design, ***Nemchand Bros.,*** Roorkee, 6th ed. reprint 2006.

Supplementary Reading:

1. S. P. Bindra, ***A Course in Highway Engg***, Dhanpat Rai Publication
2. S. C. Saxena & S. P. Arora, ***A text Book of Railway Engineering***, Dhanpat Rai & Sons.
3. R. Horonjeff and F. X. McKelvey, ***Airport Planning and Design,*** McGraw-Hill Professional, 5 edition, 2009

CE 342 TRANSPORTATION ENGINEERING 3 Credits [3-0-0]

Highways: Introduction, Road Development plans and programmes; Surveys: Location surveys- Principles of alignment, Traffic surveys; Geometric design: Cross-sectional elements, Sight distance, Horizontal and vertical alignments, Channelization; Pavement materials: Subgrade soil, Aggregates, Bituminous binders; Construction: Embankment, Soil stabilization, Non-bituminous sub-base, Non-bituminous and bituminous base courses, bituminous surface courses, Concrete pavements; Basic principles of pavement design; Drainage, Evaluation and maintenance of highways, Salient features of hill roads; Bridges: Classification of bridges, Investigations and data collection for location of bridge site, Calculation of runoff under bridges, Determination of water way, Economic span, Bridge foundations, Piers and abutments, Superstructures, Loadings, Erection of bridge spans, Temporary bridges and causeways

Essential Reading:

1. P. Chakraborty & A. Das, ***Principles of Transportation Engg***, PHI Publication, 1st Ed. 2nd reprint 2005.
2. S. K. Khanna & C. E. G. Justo, ***Highway Engineering***, Nemchand Bros, Roorkee, 8th edition 2001, Reprinted 2003.
3. D. J. Victor, ***Essentials of Bridge Engineering***, Oxford & IBH, 6th ed., 2007.

Supplementary Reading:

1. L. R. Kadiyali, ***Principles and Practice of Highway Engg***, Khanna Publications, 4th Ed. 2003.
2. C. S. Papacostas & P. D. Prevedouros, ***Transportation Planning and Planning***, PHI, 3rd ed. 2002.
3. C. J. Khisty & B. K. Lall, ***Transportation Engg: An introduction***, PHI, 3rd ed. 2006.
4. V. K. Raina, ***Concrete bridge practice – Vol I, II and III***, Tata McGraw Hill Pub. Co. Ltd., New Delhi 1st Ed. 1996.

CE 351 HYDRAULICS AND HYDRAULIC MACHINES 4 Credits [3-1-0]

Dimensional Analysis and Model Testing: Dimensional homogeneity, Dimensional analysis, Rayleigh's method and Buckinghum's methods, Similarity laws and model studies, Distorted models; Impact of Jet on Vanes: Dynamic pressure on fixed and moving flat plates and Curved vanes, Work done and efficiency; Turbines: Various types, Study of Pelton, Kaplan and Francis turbines, Velocity triangles, Efficiency, Work done, Specific speed, Unit quantities, Performance of turbines, Governing of turbines, Cavitation in reaction turbines, Principle of similarity applied to turbines; Pumps: Centrifugal Pumps- Classification, Blade angle, Velocity triangle, Efficiency of centrifugal pumps, Specific speed, characteristic curves, Multistage pumps, Pumps in series and parallel, Principle of similarity applied to pumps, NPSH. Reciprocating Pumps- Principle of working. Slip, Work done, effect of acceleration, Frictional resistance, Separation, Air vessels; Measurements and Machines: Hydraulic ram, Hydraulic intensifier, Hydraulic accumulator, Hydraulic crane, Hydraulic lift, Hydraulic press. Point gauge, Pitot tube, Current meter, Venturi meter, Orifice meter, Orifices and Mouth pieces, Notches and Weirs.

Essential Reading:

1. S. K. Som and G. Biswas, ***Fluid Mechanics and Fluid Machines***, Tata. McGraw Hill Publishing Company Ltd., 2004.
2. R. J. Garde and A. C. Mirajgaokar, ***Engineering Fluid Mechanics***, Scitech Publications India Ltd., 2003.

Supplementary Reading:

1. K. C. Patra, ***Engineering Fluid Mechanics and Hydraulic Machines***, 1st Edition, Narosa Publishing House, 2008.
2. R. K. Rajput, ***Fluid Mechanics & Hydraulic Machines***, S. Chand & Company ltd., New Delhi.
3. S. R. Rutham, ***Hydraulic Fluid Mechanics and Fluid Machines***, Dhanpat Rai Publishing Company, New Delhi.

CE 352 ADVANCED FLUID MECHANICS 4 Credits [3-1-0]

Dynamic of Fluid Flow, One-Dimensional method, The Nervier Stokes Equation, Limiting Case, Applications. Boundary Layer Theory for low and high Viscosity, Boundary Layer thickness, Prandtl's Equation, Momentum Integral Equation, Pressure Distribution in boundary layer. Dimension analysis and similarities, Buckingham theorem, types of similarities, forces influencing hydraulic phenomenon, significance of dimensionless numbers, distorted model, and model proto type similarity law; Laminar and Turbulent Flow in Pipes, Reynolds experiment, mechanism of turbulent flow, Prandtls mixing length theory, Karmans similarity hypothesis, Universal velocity distribution near solid boundary, Hydro dynamically smooth and rough pipes. Power law for velocity distribution, Nikuradse experiment, Ageing of Pipes; Compressible Fluid Flow, Equation of motion, continuity equation and energy equation. Stagnation point and its properties, flow through ducts of varying areas, flow through convergent and divergent nozzles, effects of compressibility, shock waves, supersonic expansion and contraction; Ideal Fluid Flow, Circulation and Vorticity, Source and sink, combining flow field by super position, combined flow field for Engineering importance. Doublet in rectilinear flow and Doublet with Circulation. Flow past a cylinder curved flow and with circulation and their different combinations; Unsteady flow in bounded systems, Quasi-steady flow, unsteady flow in pipes and open channel flow. Finite difference representation of depth dependent-discharge, Simulation of unsteady flow in pipes, channels and ducts. Development of St. Venant equation of continuity and motion Non uniform flow in open channel flow, equation of gradually varied flow. Classification of water surface profiles, location of hydraulic jump.

Essential Reading:

1. J. F. Douglas, J. M. Gasiorek, J. A. Swaffield, ***Fluid Mechanics***, Pearson Education.
2. R. J. Garde, A. G. Mirajgaoker, ***Engineering Fluid Mechanics***, SciTech Publication, Chennai.

Supplementary Reading:

1. V. L. Streeter, ***Fluid Mechanics***, McGraw-Hill Book, New York, 1971.
2. J. A. Liggett and D. A. Caughey, ***Fluid Mechanics: An interactive text***, ASCE press.
3. A. K. Jain, ***Fluid Mechanics***, Khanna Publishers, Delhi.
4. K. C. Patra, ***Engineering Fluid Mechanics and Hydraulic Machines***, Narosa publishing house, New Delhi.
5. ***Fluid Mechanics and Application with CD roams***, CENGEL, Prentice Hall, New Delhi.

CE 371 GEOTECHNICAL ENGINEERING LABORATORY 2 Credits [0-0-3]

Visual Identification of soil; Grain Size Analysis (Mechanical Sieve Analysis, Wet Analysis); Atterberg's limit (Liquid limit, Plastic Limit, Shrinkage Limit), Free Swell Test; Determination of Field Density by Core Cutter Method and by Sand Replacement Method; Specific Gravity of Soils (Fine and Coarse Grained); Determination of OMC & MDD by Using Light Compaction Test, Relative Density of Coarse Grained Soils; California Bearing Ratio Test; Direct Shear Test, Vane Shear Test; Unconfined Compression Shear Test; Permeability test (constant head and Falling head test); Triaxial shear Test; Consolidation Test.

Essential Reading:

1. Geotechnical Engineering Laboratory Manual.

Supplementary Reading:

1. Indian Standard Code IS: 2720

CE 372 STEEL STRUCTURES DESIGN PRACTICE 2 Credits [0-0-3]

Analysis and design of Roof trusses; Analysis and design of Plate Girder Bridge; Analysis and design of Elevated water tank.

CE 373 ADVANCED SURVEYING FIELD WORK 2 Credits [0-0-3]

Permanent adjustment of theodolite; Theodolite traverse; Tacheometry contouring; Triangulation; Trigonometrical leveling; Study of Total station and measurements

CE 374 TRANSPORTATION ENGINEERING DESIGN PRACTICE 2 Credits [0-0-3]

Design and drawing of a HPC culvert to cater to a given stream flow; Design and drawing of a RCC slab culvert on a highway; Design and drawing of superstructure of a T-Beam Bridge; Design and drawing of a RCC Box culvert to cater to a given stream flow and terrain condition; Design of suitable foundation for a pier/abutment of a bridge; Study of geometric design characteristics of highways; Practice on blending of aggregates; Calculation of earthwork for highways and railways; Setting out of horizontal and vertical curves; Design of flexible pavement

Essential Reading:

1. S. K. Khanna and C. E. G. Justo, ***Highway Engineering***, Nemchand Bros, Roorkee, 8th edition 2001, Reprinted 2003.
2. D. J. Victor, ***Essentials of bridge engineering***, Oxford & IBH, 6th ed., 2007.

Supplementary Reading:

1. P. Chakraborty and A. Das, ***Principles of Transportation Engg***, PHI Publication, 1st Ed. 2nd reprint 2005.
2. V. K. Raina, ***Concrete bridge practice – Analysis, design and Economics***, Tata McGraw Hill Pub. Co. Ltd., New Delhi, 2nd Ed. 2008.

CE 375 STRUCTURAL ENGINEERING DESIGN PRACTICE 2 Credits [0-0-3]

Design and detailing of continuous beams and lintels; Design and detailing of one-way and two-way slabs; Design and detailing of staircases; Design and detailing of axially loaded and eccentric columns; Design and detailing of axially loaded and eccentric column footings.

CE 376 ENVIRONMENTAL ENGINEERING DESIGN PRACTICE 2 Credits [0-0-3]

Design of river intake and pump house; Design of water treatment plants: Mixing tank; Flocculator; Sedimentation tank; Rapid gravity filter; Wash water tank; Under drainage system. Design of effluent treatment plant: Screening tank; Grit chamber: Primary clarifier; Trickling filter; Aeration tank; Secondary clarifier; Design of septic tank and soakage pit; Design of Air pollution Control Systems; Particulate and Gaseous pollutant control.

Essential Reading:

1. A. P. Sincero & G. Sincero, ***Environmental Engineering: A Design Approach***, Prentice Hall.
2. H. S. Peavy, D. R. Rowe & G. Tchobanoglous, ***Environmental Engg***, McGraw Hill.

Supplementary Reading:

1. M. L Davis and D. A. Cornwell, ***Introduction to Environmental Engg***, McGraw Hill.
2. G. Kiely, ***Environmental Engineering***, McGraw Hill.
3. C. D. Cooper and F. C. Alley, ***Air Pollution Control: A Design Approach***, McGraw Hill.

CE 377 FLUID MECHANICS AND HYDRAULIC MACHINES LABORATORY 2 Credits [0-0-3]

Verifications of momentum equation; Verifications of stokes apparatus; Calibration of Venturimeter; Verifications of Bernoulli's equation through a convergent and divergent passage; Study of Major losses in Pipes; Study of Minor losses in Pipes; Velocity distribution in a pipe flow; Velocity distribution in open channel flow; Flow through Pipes; Reynolds's experiment; Calibration of Notch; Experimental calculation of Metacentric Height; To study the performance characteristics of a Pelton turbine; To study the performance characteristics of a Francis turbine; To study the performance characteristics of a Kaplan turbine; To study the characteristics of a single stage Centrifugal pump; To study the Overall efficiency and percentage slip of a Reciprocating Pump; To determine the Critical Cavitation Number of a test rig.

CE 378 ENVIRONMENTAL ENGINEERING LABORATORY 2 Credits [0-0-3]

A. Water Quality Analysis: Determination of pH (Electrometric and Colorimetric); Determination of turbidity by using Nephelometer; Determination of alkalinity and acidity; Optimum dose of coagulants by jar test; Total Hardness; Total solids and suspended solids; Residual chlorine; Chlorides; Chemical Oxygen Demand; Biochemical Oxygen Demand; Dissolved Oxygen; **B. Ambient Air Quality Analysis:** Respirable Particulate Matter (PM_{10}).; Total Suspended Particulate matter (TSP); Determination of SO_2 in ambient air; Determination of NO_x in ambient air. **C. Noise Pollution measurement:** Indoor and ambient noise level analysis; **D. Microbiological Analysis of Water:** Microbiological culture analysis of bacterial samples; MPN Test.

Laboratory Manual:

1. Geotechncial Engineering Laboratory Manual.
2. Environmental Engineering Laboratory Manual.
3. Standard Methods for the Examination of Water and Wastewater- AWWA, APHA, WEF, (USA), 20th edition, 2001.

CE 401 ESTIMATION, COSTING AND CONSTRUCTION MANAGEMENT 4 Credits [3-1-0]

Methods of Estimation: Estimation of quantities for building, Arches, Sanitary and water supply works, Irrigation works, Road works.; Specifications: General specification, Details specification for different building items; structural works, road works.; Analysis of Rate: Analysis of rates for Earth work, Cement concrete, RCC, Brick work, plastering, etc.; Contracts: Different methods of carrying out work contract system, Contract document, Types of contract, measurement book. Method of tendering; Construction management: Project, Project development process, project evaluation, Finance, material and man power development, project management, Construction scheduling, Bar charts, activity times, Network analysis, elements of PERT and CPM.

Essential Reading:

1. B. N. Dutta, ***Estimating and Costing in Civil Engineering***, UBS Publishers, 23rd Edition.
2. B. Sengupta and H. Guha, ***Construction Management and Planning***, TMG.

Supplementary Reading:

1. M. Chakraborti, ***Estimating, Costing, Specification and valuation in Civil Engineering***, Published by author, Calcutta.
2. B. M. Dhira & P. S. Gahlot, ***Construction planning and management***, New Age International Pvt. Ltd.

CE 403 OPTIMIZATION METHODS IN ENGINEERING 3 Credits [3-0-0]

Introduction: Need for engineering optimal design, Optimum design formulation: Design variable, objective function and constraints.; Unconstrained optimization methodsSingle variable optimization methods: Region elimination method – Golden section search, Interval halving method; Gradient based method – Newton-Raphson, bisection and secant method. Multi variable optimization methods: Direct search method: Hooke-Jeeve pattern search, simplex reflection search, Powell's conjugate direction search. Gradient Based methods: Cauchy's steeped descent, Newton's method, Levenberg-Marquardt's method, Fletcher- Reeve method.; Constrained optimization methods Kuhn Tucker condition, Penalty function method, Augmented Lagrangian method, sequential unconstrained minimization, cutting plane method. Linear Programming: Simplex method, Dual problem; Introduction to Evolutionary algorithms: Need for evolutionary algorithms, Type of evolutionary methods, Introduction to Genetic algorithm (GA), Difference and similarities between GA and traditional methods. Basic operations of GA: reproduction, crossover, mutation and elitism. Binary coded and Real coded GA.

Essential Reading:

1. J. S. Arora, ***Introduction to Optimum Design***, Elsevier, 2nd Edition, 2004.
2. K. Deb, ***Optimization for Engg. Design: Algorithms & Examples***, Prentice Hall India, 2006.

Supplementary Reading:

1. S. S. Rao, ***Engineering Optimization: Theory & Practice***, New Age International (P) Ltd, 3rd Edition, 1996, Reprint: June, 2008.
2. K. Deb, ***Multi-Objective Optimization Using Evolutionary Algorithms***, John Wiley, 2003.

CE 404 QUALITY MANAGEMENT 3 Credits [3-0-0]

Introduction; Cause and Effect Analysis; Failure Mode and Effect Analysis; Hypothesis Test; Introduction to Lean Principle; Introduction to Six Sigma; DMAIC methodology; Organization of Data, Pareto Analysis, Scatter Diagrams, Control Charts, Linear Regression; Statistical Applications and Methods; Probability Distributions; Basic Statistical Process Control

Essential Reading:

1. P. S. Pande et al, R. P. Neuman, R. R. Cavanagh, ***The Six Sigma Way: How GE, Motorola, and Other Top Companies are Honing Their Performance***, McGraw-Hill
2. S. Taghizadegan, ***Essentials of Lean Six Sigma***; Elsevier

Supplementary Reading:

1. R. S. Chalapathi, ***Developing Six Sigma Competencies***, Institute of Sigma Learning
2. P. S. Pande, ***The Six Sigma Leader: How Top Executives Will Prevail in the 21st Century***, Tata Mcgraw Hill

CE 405 DISASTER MANAGEMENT 3 Credits [3-0-0]

Cyclones: Formation, Cyclonic precipitation, anti-cyclones, Flood: Flood and its estimation, Flood warning, Flood protection measures. Earthquake: Causes of earthquake, plate tectonics, seismic zoning map, Characteristics of strong ground motions & attenuation, progressive collapse of structures, damage assessment, rehabilitation and retrofitting of structures. Environmental disaster: Impact assessment studies, computation and preparedness. Disaster management: Developing appropriate technology for disaster mitigation, Role of management teams, importance of awareness, alertness and preparedness camp. Hazard resistant design of structures.

Essential Reading:

1. K. C. Patra, ***Hydrology and Water Resources Engineering***, CRC Press, Florida, USA, 2nd Edition
2. N. Sharma, ***Earthquake resistant building construction***, S. K. Kataria & Sons, New Delhi.

Supplementary Reading:

1. K. Subramanian, ***Engineering Hydrology***, Tata McGraw Hill, New Delhi.
2. V. P. Singh, ***Elementary Hydrology***, Prentice Hall of India.
3. P. C. Sinha, ***Disaster Mitigation, Preparedness, Recovery and Response***, SBS Publishers & Distributors Pvt. Ltd.
4. D. P. Coppola, ***Introduction to International Disaster Management***, Butterworth-Heinemann.
5. F. B. Friedman, ***Practical Guide to Environmental Management***, McGraw Hill.

CE 407 OPTIMIZATION METHODS & ITS APPLICATIONS IN CIVIL ENGINEERING 3 Credits [3-0-0]

Introduction: Need for engineering optimal design, Optimum design formulation: Design variable, objective function and constraints.; Unconstrained optimization methodsSingle variable optimization methods: Region elimination method – Golden section search, Interval halving method; Gradient based method – Newton-Raphson, bisection and secant method. Multi variable optimization methods: Direct search method: Hooke-Jeeve pattern search, simplex reflection search, Powell's conjugate direction search. Gradient Based methods: Cauchy's steeped descent, Newton's method, Levenberg-Marquardt's method, Fletcher- Reeve method.; Constrained optimization methods Kuhn Tucker condition, Penalty function method, Augmented Lagrangian method, sequential unconstrained minimization, cutting plane method.; Introduction to Evolutionary algorithms: Need for evolutionary algorithms, Type of evolutionary methods, Introduction to Genetic algorithm (GA), Difference and similarities between GA and traditional methods. Basic operations of GA: reproduction, crossover, mutation and elitism. Binary coded and Real coded GA.; Application of Optimization techniques: Water resource planning management, Structural Optimization, Transportation planning and Management, Slope stability and optimal dimensioning of foundations multi-objective optimization models

Essential Reading:

1. J. S. Arora, ***Introduction to Optimum Design***, Elsevier, 2nd Edition, 2004.
2. K. Deb, ***Optimization for Engg. Design: Algorithms & Examples***, Prentice Hall India, 2006.

Supplementary Reading:

1. S. S. Rao, ***Engineering Optimization: Theory & Practice***, New Age International (P) Ltd, 3rd Edition, 1996, Reprint : June, 2008
2. K. Deb, ***Multi-Objective Optimization Using Evolutionary Algorithms***, John Wiley, 2003

CE 411 PLATE AND SHELL STRUCTURES 3 Credits [3-0-0]

Pure Bending of Plates: Slope & curvature of slightly bent plates, Relations between bending moments and curvature in pure bending of plates, Strain energy in Pure bending of plates.; Symmetrical bending of Circular plates: Differential equation for symmetrical bending of laterally loaded circular plates, uniformly loaded circular plates, Circular plates with circular hole at center, circular plate concentrically loaded.; Small deflections of laterally loaded plates: Differential equation of the deflection surface, Boundary conditions, Simply supported rectangular plates under sinusoidal load, Navier solution for simply supported rectangular plates, Further applications of the Navier solution, Alternate solution for simply supported and uniformly loaded rectangular plates, Concentrated load on simply supported rectangular plates; Classification of shell structures, importance of membrane theory of shells, shells in the form of a surface of revolution and loaded un-symmetrically with respect to their axes, spherical dome, conical shells, cylindrical shells, Elliptic paraboloid, hyperbolic parabolod and conoids.; General theory of cylindrical shells; Circular cylindrical shell loaded symmetrically with respect to its axis, particular cases of symmetrical deformations of circular cylindrical shells, cylindrical tanks of uniform wall thickness.; Design of spherical domes with/ without lanterns at top.

Essential Reading:

1. S. P. Timoshenko & W. Kriegar, ***Theory of plates and shells***, Mc Graw Hill International, New Delhi.
2. G. S. Ramaswamy, ***Design and construction of concrete shells Roofs***, CBS Publishers, Delhi.

Supplementary Reading:

1. D. P. Billington, ***Thin shell concrete structures***, Mc Graw Hill international, New York
2. W. T. Marshall, ***Design of cylindrical shell roofs***, E & FN SPON, London.

CE 412 PRE-STRESSED CONCRETE 3 Credits [3-0-0]

Historical developments, Basic concepts, types, different systems, Materials- Steel, concrete and their properties; Losses of prestress, Design of simply supported beams- Basic assumptions, stress in concrete and steel due to load and prestress, pressure line and internal resisting couple, kern distance, cracking moment, general approach for service load design, graphical methods, Lin’s method, limit state design as per IS code, partial prestressing; Shear and principal stresses in homogenous elastic beams, Design of reinforcements for shear and torsion, Stress distribution in end block—Magnel’s method, Guyen’s method, Rowe’s method, IS code method; Design of pipes and tanks, railway sleepers, electric posts, composite construction. Beam deflection- short term and long term deflections; Design of continuous beam-Principles of design of prismatic continuous beams of two and three equal, unequal spans, with variable moments of inertia. Cap cables. Jaeques Muller’s theorem.

Essential Reading:

1. Y. Guyen, ***Prestressed concrete Vo1-I and II***, John Wiley & Sons, New York, 1960.
2. T. Y. Lin and H. Burns, ***Design of prestressed concrete structures***, Ned- John Wiley & Sons, New York, 1982.

Supplementary Reading:

1. E. W. Bennet, ***Prestressed concrete: Theory and design***, Chapman and Hall, London, 1962.
2. N. Krishnaraju, ***Prestressed concrete***, Tata McGraw Hill, New Delhi, 2004.
3. S. K. Mallik & A. P. Gupta, ***Prestressed concrete***, Oxford and IBH, New Delhi, 1982.

CE 413 ADVANCED DESIGN OF REINFORCED CONCRETE STRUCTURES 3 Credits [3-0-0]

Design of combined footings, raft footing.; Design of cantilever and counterfort type retaining walls.; Design of water tanks-Underground, elevated and Intze type.; Design of portal frames and domes.

Essential Reading:

1. S. N. Sinha, ***Reinforced Concrete Design***, Tata McGraw Hill.
2. P. Dayaratham, ***Design of Reinforced Concrete Structures***, New Delhi, Oxford and IBH Publishing Co.
3. Relevant IS codes.

Supplementary Reading:

1. H. J. Shah, ***Reinforced Concrete, Vol-I***, Charotar Publishing House
2. B. C. Punmia, A. K. Jain and A. K. Jain, ***Comprehensive RCC Designs***, Laxmi Publications
3. J. Krishna and O. P. Jain, ***Plain and Reinforced Concrete Vol-I & II***, Nem Chand and Bros., Roorkee

CE 415 EARTHQUAKE AND WIND RESISTANT DESIGN OF STRUCTURES 3 Credits [3-0-0]

Review of damages to buildings due to wind and earthquake; SDOF Systems: Free and Forced Vibrations, Damping, Response Spectrum; MDOF Systems: Formulation of equations of motion, Natural Frequencies and Modes; Equivalent Static Analysis; Response Spectrum Analysis; Wind and Earthquake Resistant Design Philosophy; Ductility, Design and Detailing for Ductility; Code Provisions for Wind and Earthquake Effects.

Essential Reading:

1. E. Simiu & R. H. Scanlan, ***Wind Effects on Structures: Fundamentals and Applications to Design***, Dover Publications
2. A. K. Chopra, ***Dynamics of Structures: Theory and Applications to Earthquake Engineering*** (3rd Edition), Prentice-Hall of India.

Supplementary Reading:

1. IS 1893(Part 1), ***Criteria for Earthquake Resistant Design of Structures : Part 1 General provisions and Buildings***, 2002
2. IS 13920, ***Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces – Code of Practice,*** 1993

CE 418	PROBABILITY AND RELIABILITY METHODS IN CIVIL ENGINEERING	3 Credits [3-0-0]

CE 421	GROUND IMPROVEMENT TECHNIQUES	3 Credits [3-0-0]

Introduction: Engineering properties of soft, week and compressible deposits, Natural on land, off-shore and Man-made deposits. Role of ground improvement in foundation engineering, methods of ground improvement, Selection of suitable ground improvement techniques; In-situ methods: In-situ densification soils, Dynamic compaction and consolidation, Vibrofloation, Sand pile compaction, Preloading with sand drains and fabric drains, Granular columns, Micro piles, Soil nailing, Ground Anchors, Lime piles, Injections, Thermal, Electrical and Chemical methods, Electro osmosis, Soil freezing; Reinforced Soil: The Mechanism, Reinforcement materials, Reinforcement - Soil Interactions, Geosynthetics, Principles, Analysis and Design of Reinforced Retaining Structures, Embankments and Slopes, soil nailing.

Essential Reading:

1. R. M. Korner, ***Design with Geosynthetics***, Prentice Hall, New Jersey, 3rd Edn. 2002.
2. P. P. Raj, ***Ground Improvement Techniques***, Tata McGraw Hill, New Delhi, 1995.

Supplementary Reading:

1. B. M. Das, ***Principles of Foundation Engineering*** Thomson, Indian Edition, 2003.
2. G. V. Rao & G. V. S. Rao, ***Text Book on Engineering with Geotextiles***, Tata McGraw Hill
3. T. S. Ingold & K. S. Miller, ***Geotextile Hand Book***, Thomas Telfrod, London.
4. N. V. Nayak, ***Foundation Design Manual***, Dhanpat Rai and Sons, Delhi.

CE 423	ADVANCED FOUNDATION ENGINEERING	3 Credits [3-0-0]

Shallow Foundation: Location and depth of foundation, Determination of bearing capacity of shallow foundation on cohesive and cohesionless soils, contact pressure and related study for rigid and flexible foundation. Floating or compensating foundations.; Deep Foundations:

Piles: Load carrying capacity of single and pile group in cohesive and cohesionless soils (both end bearing end friction piles). Settlement of pile foundation. Negative friction and its effect on pile capacity.

Well foundations: Types and components of well. Determination of depth, Size and number of wells under a heavy footing or pier, Phenomena of bottom heaving. Well sinking and related problems of sinking of well foundations.

Foundation on Expansive Soils; Identification / Characteristics of expensive soils, Swelling pressure and its effect on foundations for single end multi-storeyed buildings. Under-reamed piles, Accepted precautionary measures.; Machine Foundations: Types of machines, Free and forced vibrations, vibration isolations, Design consideration for simple machine foundations under reciprocating, centrifugal and impact type machines.; Recent developments in foundation engineering.

Essential Reading:

1. S. Saran, ***Analysis and Design of Substructures***, Oxford and IBH publication, New Delhi,
2. B. M. Das, ***Principles of Foundation Engineering,*** Thomson, Indian Edition, 2003.

Supplementary Reading:

1. J. E. Bowles, ***Foundation Analysis and Design,*** Mc Graw Hill (2001)
2. P. Srinivasulu & C. V. Vaidyanathan, ***Hand Book of Machine Foundation***, Tata Mc Grow Hill Pub Co. Ltd., New Delhi.
3. F. H. Chen, ***Foundations of Expansive Soil,*** Elsevier Science Publisher, Amsterdam.

CE 424	EARTHQUAKE GEOTECHNICAL ENGINEERING	3 Credits [3-0-0]

Earthquakes: Causes and characteristics (magnitude, intensity, accelarograms), response spectra, attenuation of ground motion. Estimation of seismic hazards (deterministic and probabilistic).; Introduction to vibratory motion: Waves in Elastic Medium; Dynamics of Discrete: Systems, Vibration of single and multiple degree of freedom systems. Free and forced vibrations (regular and irregular excitation).; Dynamic properties of soils: Determination of site characteristics, local geology and soil condition, site investigation and soil test, Laboratory and in-situ tests; Site response to earthquake. Seismic Microzonation.; Liquefaction of soils: Fundamental concept of liquefaction, assessment of liquefaction susceptibly from SPT and CPT,; Seismic response of soil structure system, seismic bearing capacity of shallow foundation, design of pile foundation in liquefiable ground. Pseudo-static analysis and design of earth retaining structures and soil slopes. Estimation of earthquake-induced deformation.

Essential Reading:

1. S. L. Kramer, ***Geotechnical Earthquake Engineering***, Prentice hall, international series, Pearson Education (Singapore) Pvt. Ltd., 2004.
2. S. Saran, ***Soil Dynamics and Machine Foundation***, Galgotia publications Pvt. Ltd., New Delhi 1999.

Supplementary Reading:

1. A. Ansal, ***Recent Advances in Earthquake Geotechnical Engineering and Microzonation***, Springer, 2006.
2. I. Towhata, ***Geotechnical Earthquake Engineering***, Springer, 2008.

CE 425	ENVIRONMENTAL GEOTECHNICS	3 Credits [3-0-0]

Introduction: Forms of waste, engineering properties (determination and typical values), subsurface contamination.; Selection of waste disposal sites: Site selection – selection criteria and rating; Solid waste disposal: Ash Disposal facilities- Dry disposal, waste disposal, Design of ash containment system, Stability of ash dykes; Contaminant transport through porous media: mechanisms- addective and dispersion; Municipal and hazardous waste landfill: Types- Dry cell, wet cell, bioreactor, Design- clay liners, geosynthetic clay liners for waste containment, cover and gas collection system.; Remediation: Principle- planning, source control, soil washing, bioremediation.

Essential Readings:

1. K. R. Reddy & H. D. Sharma, ***Geo - Environmental Engineering: Site Remediation, waste containment, and emerging waste management technologies***, John Willey, 2004.
2. R. N. Yong, ***Geoenvironmental Engineering: Contaminated Ground: Fate of Pollutions and Remediation***, Thomson Telford, 2000.

Suggested Readings:

1. L. N. Reddy & H. I. Inyang, ***Geoenvironmental Engineering: Principles and Applications***, Marcel Dek, 2000.

CE 426	SOIL STRUCTURE INTERACTION	3 Credits [3-0-0]

Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behaviour, Time dependent behaviour.; Beam on Elastic Foundation- Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness. Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.; Elastic Analysis of Pile: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap.; Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Sub grade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts.

Essential Readings:

1. R. O. Davis, A. P. S. Selvadurai, ***Elasticity and Geomechanics***, 1996, Cambridge University Press.
2. H. G. Poulos and E. H. Davis, ***Pile Foundation Analysis and Design***, John Wiley, 1980.

Supplementary Readings:

1. L. C. Reese, ***Single piles and pile groups under lateral loading***, Taylor & Francis, 2000
2. E. S. Melerski, ***Design Analysis of Beams, Circular Plates and Cylindrical Tanks on Elastic Foundation***, Taylor and Francis, 2006.
3. G. Jones, ***Analysis of Beams on Elastic foundation***, Thomas Telford, 1997.

CE 428	SOIL DYNAMICS AND INDUSTRIAL FOUNDATIONS	3 Credits [3-0-0]

Vibration of elementary systems, Analysis of systems with Single degree and multi-degree of freedom. Natural frequencies of continuous systems; Elastic Constants of soil and their experimental determination. Effect of vibration on soil properties; Bearing capacity of dynamically loaded foundations.; Principles of Machine foundation design, Experimental and analytical determination of design parameters.; Design of foundations for turbines, vertical and horizontal reciprocating engines; forge hammers, Effect of machine foundation on adjoining structures, vibration isolation.

Essential Readings:

1. S. Saran, ***Soil Dynamics and Machine Foundations***, Galgotia Publications Private Ltd. 1999.
2. N. S. V. K. Rao, ***Vibration Analysis and Foundation Dynamics***, Wiley New Delhi, 1998.

Supplementary Readings:

1. B. M. Das, ***Principles of Soil Dynamics***, Thomsons Engineering, 1992.
2. K. G. Bhatia, ***Foundations For Industrial Machines***, D-CAD Publishers, 2008.
3. A. Major, ***Vibration analysis and design of foundations for machines and turbines: Dynamical problems in civil engineering***, Akademiai Kiado Budapest Collets Holding Ltd., 1962.

CE 432	ENVIRONMENTAL BIOTECHNOLOGY	3 Credits [3-0-0]

Structure of prokaryotic and eukaryotic cells; Types of microorganisms; Metabolic classification of microorganisms. Microbial metabolism; Respiration and energy generation; Microbial growth; Enzyme kinetics and regulation; Bacterial genetics; Structure of DNA and RNA; Transcription and translation; Gene expression and regulation; Gene transfer and recombinant DNA technology; Microbial systems of bioremediation; Factors influencing bioremediation (environmental factors, physical factors and chemical factors); Genetic responses of microorganisms to the presence of pollutants (plasmid coded inducible degradative enzymes); Application of genetically engineered microorganisms for hazardous waste management; Microbial transformation reactions (aerobic and anaerobic biotransformations); Microbial detoxification of specialty chemicals (insecticides, herbicides, fungicides, polychlorinated biphenyls, heavy metals); Bioremediation systems and processes (solid, liquid and slurry phase bioremediation); Microbial cleaning of gases (biofiltration and bioscrubbing); In situ bioremediation; Laboratory scale biotreatability studies for bioremediation; Management of bioremediation project.

Essential Reading:

1. B. E. Rittmann, P. L. McCarty, ***Environmental Biotechnology- Principles and Applications***, Mc Graw Hill Int. 2000.
2. B. B. C. Banerjee, ***Environmental Biotechnology***, Oxford University Press, 2008.

Suggested Reading:

1. Scragg, ***Environmental Biotechnology***, Oxford Univ Press, 2005.
2. G. M. Evans, ***Environmental Biotechnology: Theory and Application***, Wiley, 2002.
3. R. M. Maier, I. L. Pepper, and C. P. Gerba, ***Environmental Microbiology***, Academic Press, 2000.
4. D. A. Vaccari, P. F. Strom, J. E. Alleman, ***Environmental Biology for Engineers and Scientists***, Wiley-Interscience, 2005.

CE 436	ENVIRONMENTAL MANAGEMENT IN INDUSTRY	3 Credits [3-0-0]

Nature and characteristics of industrial wastes; Prevention versus control of industrial pollution; Linkage between technology and pollution prevention; Tools for clean processes, reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications; Unit operations in separation technology; Separation technologies as tools for waste minimization. Process optimization for cleaner industrial processes; Flow sheet analysis; Energy and resource (material and water) audits for efficient usage and conservation; Waste audits, emission inventories and waste management hierarchy for process industries; Environmental regulations and policies; Environmental protection laws and acts; Environmental management systems; Strategies for management of resources, Corporate and international charters and protocols; Risk assessment; Environmental impact assessment; Industrial ecology, Pollution prevention; Waste minimisation and sustainable development; Life cycle assessment; Environmental audits; Eco-labelling of products; Performance indicators; Environmental economics. Case studies on industrial applications of cleaner technologies in chemical, metallurgical, pulp and paper, textile, electroplating, leather, dairy, cement and other industries.

Essential Reading:

1. C. J. Barrow, ***Environmental Management: Principles and Practice (Routledge Environmental Management Series)*** Routledge, 1st edition, 1999.

2. R. Sullivan, Hugh, ***Wyndham, Effective Environmental Management: Principles and Case Studies***, Allen & Unwin Academic, 2001.

Supplementary Reading:

1. F. B. Friedman, ***Practical Guide to Environmental Management***, Environmental Law Institute, USA, 9th edition 2003.
2. G. Burke, Ben R. Singh and L. Theodore, ***Handbook of Environmental Management and Technology***, Wiley-Interscience, 2nd edition, 2000.
3. B. Taylor, ***Effective Environmental, Health, and Safety Management Using the Team Approach***, Wiley-Interscience, 2005.
4. D. L. Goetsch and S. B. Davis, ISO 14000: ***Environmental Management***, Prentice Hall, 2000.

CE 441 ADVANCED TRANSPORTATION ENGINEERING 3 Credits [3-0-0]

Railway; Introduction: History, Cross section and components of railway track, Problems of multi gauge system, wheel and axle arrangements, Coning of wheels, Train resistances, hauling capacity and tractive effort, Stresses in rail, sleepers, ballast and formation.; Components of Permanent way : Rails - Types of rail section, wear and failure in rails, Creep, Rail joints, Rail fittings, check and guard rails, Sleepers – types and specifications, Ballast - specifications, Formation, drainage of track; Geometric design: Alignment, horizontal curves, super elevation, equilibrium cant and cant deficiency, Length of transition curves, Gradients and grade compensation, vertical curves; Points and crossing: Design and layout of turn-out, various types of track junctions and their configurations; Signaling and Interlocking: Control of train movements, Signals, Principles of interlocking; Airport; Air Transport Development, Aircraft characteristics, Airport planning and site selection, Obstruction and zoning laws - imaginary surfaces, approach zones and turning zones, Visual Flight Rules and Instrumental landing systems; Geometric Design of Runways and Taxiways: Runway- orientation and configuration, Basic runway length and corrections, Geometric design elements, Taxiway design, Main and exit Taxiway, Separation clearance, Holding aprons, Typical airport layouts, Terminal building, gate position; Airport marking and lighting.; Tunnel; Necessity, Tunneling vs open cut, Size and shape, Transfer of surface alignment tunneling in hard rock, soft soil and under water bodies- Use of shafts, shuttering and linings drainage and ventilation

Essential Reading:

1. S. Chandra & M. M. Agarwal, ***Railway Engineering***, Oxford University Press, New Delhi, 1st Ed. 2007.
2. S. K. Khanna & M. G. Arora, ***Airport planning and Design***, Nemchand Bros., Roorkee, 6th ed. Reprint 2006.
3. R. Srinivasan, ***Harbour Dock and Tunnel Engineering***, Charotar Publishing House, 20th Ed. 2006.

Supplementary Reading:

1. M. M. Agrawal, ***Railway Engineering***, Standard Publishers New Delhi, 2002.
2. S. C. Saxena & S. P. Arora, ***A text Book of Railway Engineering***, Dhanpat Rai & Sons.
3. R. Horonjeff and F. X. McKelvey, ***Airport Planning and Design***, McGraw-Hill Professional, 5 edition, 2009.
4. S. C. Saxena, ***Tunnel Engineering***, Dhanpat Rai & Sons, 2006.

CE 442 TRAFFIC ENGINEERING AND TRANSPORTATION PLANNING 3 Credits [3-0-0]

Traffic Engineering: Importance of Traffic engineering; Road User Characteristics, Human factors governing road user behaviour, vehicle characteristics, slow moving traffic characteristics in Indian conditions; Traffic Engg. Studies: Traffic Volume, Origin and Destination, Speed and delay: Measurements; Speed- density-volume relationships; Shock waves in Traffic flow, Headway Distribution; Highway capacity analysis- cases of different types of highways; Intersection; Parking types; Off street parking; Facilities; Traffic control devices: channelisation, rotary and Traffic signals, Traffic Signs and making.; Transportation Planning: Brief ideas about urban and regional transportation systems; Components of Transportation system planning; Land use planning, Trip generation and distribution, Traffic assignment and modal split, Optimal scheduling; Economic evaluation of transportation plans.

Essential Reading:

1. L. R. Kadyali, ***Traffic Engg & Transportation Planning***, Khanna Publishers, 4th Ed. 2003
2. C. S. Papacostas and P. D. Prevedouros, ***Transportation Planning and Planning***, PHI, 3rd Ed. 2002

Supplementary Reading:

1. C. J. Khisty & B. K. Lall, ***Transportation Engg: An introduction***, PHI, 3rd Edition. 2006.
2. P. Chakraborthy and A. Das, ***Principles of Transportation Engg***, PHI, 1st Edition, 2nd reprint 2005.
3. R. J. Salter, ***Highway Traffic Analysis and Design***, ELBS Macmilan, 2nd Edition, 1990.
4. Relevant I. R. C. Codes.

CE 443	PAVEMENT DESIGN	3 Credits [3-0-0]

Introduction: Classification of pavements, Difference between highway and runway pavements, Factors affecting Reinforced Concrete Design, Characteristics of traffic loading, Concept of VDF and Computation of design traffic; Principles of pavement design: Concepts of structural and functional failures, Performance criteria; Analysis of pavements: ESWL, Analysis of flexible and concrete pavements; Design of pavements: IRC, AASHTO and other important methods of design of bituminous and concrete pavements; Pavement evaluation techniques: Benkleman beam, Falling weight deflectometer and other equipments, Concepts of pavement maintenance management

Essential Reading:

1. E. J. Yoder & M. W. Witzack, ***Principles of Pavement Design,*** John Wiley and Sons, New York, 2nd Ed. 1975.
2. P. Chakroborty & A. Das, ***Principles of Transportation Engineering***, PHI Publication, 1st Ed., 2nd reprint 2005.

Supplementary Reading:

1. D. Croney & P. Croney, ***Design and Performance of Road Pavements***, McGraw-Hill Professional; 3 rd edition, 1997.
2. P. Chakroborty & A. Das, ***Principles of Transportation Engineering***, PHI Publication, 1st Ed., 2nd reprint 2005.
3. S. K. Khanna & C. E. G. Justo, ***Highway Engineering***, Nemchand Bros, Roorkee, 8th edition 2001, Reprinted 2003.
4. Y. H. Huang, ***Pavement Analysis and Design***, Prentice Hall, 2nd Ed. 2003.
5. Relevant I. R. C. and AASHTO Codes

CE 444	PAVEMENT MATERIALS	3 Credits [3-0-0]

Conventional aggregates: Source, preparation, grading, testing and their evaluation, Bituminous binders- Properties, testing and applications.; Bituminous mixes- Design, testing and evaluation; Modeling of bituminous binders and mixes; Materials for cement concrete and semi-rigid pavements, Design of mixes for stabilized roads; Non-conventional and new pavement materials- their application and limitations; Modern methods of testing and evaluation of paving materials

Essential Reading:

1. P. Chakraborty and A. Das, ***Principles of Transportation Engg.,*** PHI Publication, 1st Ed. 2nd reprint 2005
2. G. V. Rao, ***Principles of Transportation and Highway Engineering***, Tata Mc. Graw Hill, 1st Ed. 1995

Supplementary Reading:

1. Indian Roads Congress, ***Manual for Construction and Supervision of Bituminous works***, New Delhi, 2005.
2. Relevant IRC, ASTM and AASHTO codes and specifications.

CE 445	DESIGN OF AIRPORTS AND HILL ROADS	3 Credits [3-0-0]

Airport: Aircraft characteristics related to Airport Design, Geometric design of airport components, Reinforced Concrete Design of Airport Pavements, Maintenance and rehabilitation of airport pavements, Airport Drainage; Hill Roads: Introduction, Common problems, Geometric design and alignment surveys, Construction and maintenance, Protective structures and CD works, Drainage.

Essential Reading:

1. R. Horonjeff and F. X. McKelvey, ***Airport Planning and Design***, McGraw-Hill Professional, 5 edition, 2009.
2. S. K. Khanna, M. G. Arora and S. S. Jain, ***Airport Planning and Design***, Nem Chand Brothers, 6th Ed. reprint 2001.

Supplementary Reading:

1. N. Ashport & P. H. Wright, ***Airport Engg,*** Willey-Interscience, 3rd Ed. 1992.
2. S. K. Khanna & C E G Justo, ***Highway Engineering***, Nem Chand Bros, Roorkee, 8th Edition 2001, Reprinted 2003.
3. R. S. Gahlowt (Padam Shree), V. P. Gupta, ***Treatise on Hill Roads***, Standard Book House, New Ed., 2005.
4. Relevant IRC and AASHTO Codes and Specifications.

CE 451	IRRIGATION ENGINEERING	3 Credits [3-0-0]

ntroduction: Necessity of Irrigation in India, Advantages and disadvantages of Irrigation, Techniques of water distribution in firms. Quality of irrigation water. Crops and crop season, Consumptive use, Irrigation requirements, Estimation of consumptive use of water by climatic approaches, Irrigation efficiencies, Soil moisture-irrigation relationship; Canal Irrigation: Classification of canals, Canal losses, Alignment of canals. Design of Irrigation Canals: Design of stable channels using Kennedy's and Lacey's theory, Garret's diagram, Cross section of irrigation canals, Lining of Irrigation Canals: Advantages and economics of lining, Various types of lining, Design of lined canals, Types of Cross-Drainage Works: Types of CD works, Selection of a suitable type to suite a particular condition, Design consideration for CD works, Canal Falls: Necessity, Proper location, Types, Design and detailing of one type of fall; Weirs and Barrages: Weirs and Barrages, Types of weirs and barrages, Layout of a diversion head work, Introduction of different components of a diversion head works, Design of weirs and barrages: Bligh's creep theory, Design of weir using Bligh's theory, Lane's weighted creep theory, Khosla's theory, Khosla's method of independent variables, Exit gradient; Dams: Typical cross section, Various forces acting on gravity dam, Combination of forces for design, modes of failure and criteria for structural stability, High and low gravity dam, Design of high dam, Typical section of low gravity dam, Earth and Rock fill Dams: Types, Causes of failure, Preliminary section of an earth dam, Preliminary section of an earth dam, Seepage control in earth dams, Spillways: Descriptive study of various types of spillways; Reclamation of Water Logged and Saline Soils: Causes and control of water logging. Reclamation of saline and alkaline land, Surface and Sub-surface drainage. River training works.

Essential Reading:

1. S. K. Garg, ***Irrigation Engineering and hydraulics structures***, Khanna Publishers, 16th Edition.
2. B. Singh, ***Irrigation Engineering***, Nem Chand and Sons, Roorkee.

Supplementary Reading:

1. Varshney & Gupta, ***Theory and Design of Irrigation Structures***, Nem Chand and Bros, Roorkee.
2. I.e.Hook, ***Irrigation Engineering***, John Wiley and Sons, New York.
3. J. D. Zimmerman, ***Irrigation***, John Wiley and Sons, New York.

CE 452	WATER RESOURCES ENGINEERING	3 Credits [3-0-0]

Precipitation, its Measurement, analysis and losses: Hydrologic cycle, catchment area and watershed, Rainfall and its characteristics, Rain gauges, Non-Recording and Recording type, average rainfall over a catchments, Evapo-transpiration, Pan evaporation, pan coefficient Infiltration, W-Index and ϕ - Index; Hydrographs: Discharge formulae, characteristics of a Run off hydrograph, Unit hydrograph, S-hydrograph, Instantaneous hydrograph, synthetic Unit hydrograph, Duration Curve, Mass Flow hydrograph, Stream gauging, Flow rating curve, use of current meters for velocity measurement, Dye-dilution method of discharge measurement; Flood Control: Flood flows, Frequency studies, Statistical analysis for flood prediction, Method of flood control, Flood routing, Reservoir routing and Channel routing, River training works; Dock and Harbours: Natural and artificial Harbours, Selection of site, study of winds, tides and wave actions, Accretion and denudation, Principle of construction of Breakwaters, Quays and jetties, Wet and Floating Docks.

Essential Reading:

1. K. C. Patra, ***Hydrology & Water Resources Engg.,*** Narosa Publishing House, New Delhi, 2nd Edition.
2. K. Subramanya, ***Engineering Hydrology***, Tata McGraw Hill, 2nd Edition.

Supplementary Reading:

1. R. Srinivasan, ***Harbour, Dock and Tunnel Engineering.***
2. V. T. Chow, ***Hand book of Applied Hydrology***, McGraw-Hill Publishing Company, New York.
3. R. K. Linsely, M. A. Kohlar, J. L. H. Pauluhus, ***Hydrology for Engineers***, Tata McGraw Hill, New Delhi.
4. R. S. Varshany, ***Engineering Hydrology***, Nem Chand and Brothers, Roorkee.
5. E. M. Wilson, ***Engineering Hydrology***, Macmillan, ELBS, London.

CE 453	COMPUTATIONAL FLUID DYNAMICS	3 Credits [3-0-0]

Introduction, overview of the numerical simulation of flood flows in river channels, governing equations in flood flows in river channels. Finite difference approach, Explicit finite difference schemes, Implicit finite difference schemes, significance of model boundary conditions, affect of flow conditions within river channels and its numerical models, data requirements for numerical models of flood flows in river channels, Model calibration, understanding of the data checks necessary to ensure correct representation of the river geometry in a numerical model, calibrating numerical models of flood flows in river channels, Fundamental of Finite Volume Method and its application in water resources engineering, . Conveyance Estimation, prediction of conveyance within river channels, new Conveyance Estimation System (CES).

Essential Reading:

1. J. D. Anderson Jr. . ***Computational Fluid Dynamic***, Mc Graw Hill publications
2. K. A. Hoffman and S. T. Chang, ***Computational Fluid Dynamics*** Vol-1 and Vol-II.

Supplementary Reading:

1. Weiming Wu. . ***Computational River Dynamic***
2. Rolland Jeppson, ***Open Channel Flow: Numerical methods and Computer applications***.

CE 454 GROUND WATER HYDROLOGY 3 Credits [3-0-0]

Hydrologic cycle, Water balance, Occurrence of ground water: Origin, geological formations as aquifers, type of aquifers, groundwater basins, springs. Darcy's Law, validity of Darcy's Law permeability, laboratory and field measurement of permeability, groundwater Flow lines. Steady flow to a well, steady radial flow to a well in confined aquifer and unconfined aquifer, Unsteady radial flow into a confined aquifer, Non equilibrium Theis equation, Theis method of solution, multiple well system; Methods of constructions of deep and shallow wells: The percussion (or cable tool) method of drilling, Direct circulation hydraulic rotary method, Down the hole hammer method, well logs-receptivity logging, testing of wells for yield, Effect of irrigation, stream flow, rainfall on groundwater fluctuations, seasonal and secular variations, fluctuation due to miscellaneous causes; Surface and Subsurface investigations of groundwater: Geophysical exploration, Electrical resistivity method, aerial photo interpretation, remote sensing applications to ground water exploration, test drilling, Artificial recharge by water spreading, through pits and shaft, recharge through other methods; Ground water pollution: Municipal sources, liquid wastes from domestic uses, solid wastes, Industrial sources, tank and pipeline leakage, Mining activity, agricultural sources, septic tank and cesspools, saline water intrusion in coastal aquifers, methods to control saline water intrusion; Groundwater management: Concepts of Basin management, Equation of hydrologic equilibrium, groundwater basin investigations, conjunctive use of surface and groundwater.

Essential Reading:

1. K. C. Patra, ***Hydrology and Water Resources Engg.,*** Narosa Publishing house, New Delhi.
2. D. K. Todd, ***Groundwater Hydrology***, John Wiley and Sons.

Supplementary Reading:

1. H. M. Raghunath, ***Ground Water.***
2. S. P. Garg, ***Groundwater and Tube Wells***, Oxford and IBH Publishing Co., New Delhi.
3. V. T. Chow, ***Hand book of Applied Hydrology***, McGraw-Hill Publishing Company, New York.

CE 455 OPEN CHANNEL FLOW 3 Credits [3-0-0]

Open- channel flow and its classifications, measurement of velocity, velocity distribution, pressure distribution, specific energy, Specific force and critical state of flow, section factor for critical flow; Uniform flow, determination of roughness coefficients and the factors affecting the roughness, computation of uniform flow, flood discharge, determination of normal depth and velocity, flow in composite roughness; Design of channels for uniform flow in non-erodable and erodable with grassed channels; Dynamics of Gradually varied flow and classification of flow profile, methods of computation, Dynamics of spatially varied flow - analysis of flow profile and computation by method of numerical integration; Rapidly varied flow, classification, flow over spillway, Hydraulic Jump, types with characteristics of jump, the surface profile and location of the jump, jumps as energy decapitator, Rapidly varied flow through non-prismatic channels; Unsteady flow, dynamics of gradually varied unsteady flow, solution of unsteady flow equations, rapidly varied unsteady flow, positive and negative surges, flood routing, principle and methods of flood routing.

Essential Reading:

1. V. T. Chow, ***Open Channel Hydraulics***, McGraw-Hill Publishing Company, New Delhi, 1993.
2. F. M. Henderson, ***Open Channel Flow***, MacMillan Publishing Company, 1996.

Supplementary Reading:

1. K. G. Rangaraju, ***Flow through Open Channel***, Tata McGraw Hill, New Delhi.
2. H. Chanson, ***The Hydraulics of Open Channel Flow: An Introduction***, Elsevier.
3. K. Subramanya, ***Flow in Open Channel***, Tata McGraw Hill, New Delhi.
4. ***River Hydraulics***, (Technical Engineering and Design Guides as adapted from the U. S. Army Corps of Engineers, No. 18) New York: ASCE Press.
5. H. Rouse, ***Engineering Hydraulics***, John Wiley and Sons.

CE 456 WATER RESOURCES PLANNING AND MANAGEMENT 3 Credits [3-0-0]

Hydrologic Cycle: Rainfall, Rain gauge, Evaporation, Transmission, Infiltration, Rainfall excess, Base flow, Average rainfall, Runoff, DRH; River basins: Catchment area, River stages in hilly-plain and deltaic area. Storage structures: Dams, Weirs, Barrages their location. Classification of dams and Multipurpose dams; Requirement of water for various needs: Domestic, Irrigation, Power generation etc, Reservoir planning. Rain water harvesting for Domestic Industrial and Irrigation Uses; Ground water: Types of aquifers, their properties, ground water table, Ground water yield, well hydraulics.

Essential Reading:

1. K. C. Patra, ***Hydrology and Water Resources Engineering***, Narosa Publishing House, New Delhi, 2nd Edition, 2007
2. K. Subramanian, ***Engineering Hydrology***, Tata McGraw Hill, New Delhi.

Supplementary Reading:

1. V. P Singh, ***Elementary Hydrology***, Prentice Hall of India.

CE 471	COMPUTER AIDED DESIGN PRACTICE	2 Credits [0-0-3]

Revisiting different methods of analysis of beams and frames, different philosophies of design of RCC structures.; Concept of computer aided design, introduction of software packages used for analysis and design of structures including STAAD and SAP.; Analysis and design of a double storied frame using STAAD, SAP and check by any of analytical methods including Kani's method.; Drawing of any utility building (two storied and above) like residential complex, software office, Hotel, hospital, Bank, post office at different places of the country using any graphical package including Autocad, analysis and design using software like STAAD Pro, SAP etc.; Concept of earthquake resistant design of structures in the above design of utility buildings.

Essential Reading:

1. Online manuals of the software used for drawing and design.

CE 472	STRUCTURAL ENGINEERING LABORATORY	2 Credits [0-0-3]

Basic tests for cement and concrete; Mix design of concrete of different grades; Tensile strength of different types of steel rebars; Tensile and Flexural strength of concrete of different grades; Testing of simply supported RCC beams for flexural failure; Testing of simply supported RCC beams for shear failure; Testing of RCC column; Non-destructive test of concrete; Permeability of concrete; Vibration analysis of plates.

Essential Reading:

1. Structural Engineering laboratory manual
2. Relevant BIS Codes of practice for mix design, rebar testing, concrete design etc.

CE 473	GEOTECHNICAL ENGINEERING DESIGN PRACTICE	2 Credits [0-0-3]

Interpretation and use of In-situ tests (SPT, CPT, PLT, PMT, DMT) for design of foundations; Geotechnical Design of shallow footing for compression, bending and uplift; Design of piles under compression, lateral and uplift forces; Design of well foundation; Design of soil slopes; Concept of Computer aided design and use of software packages for analysis and design of : Soil slopes with and without reinforcement; Sheet pile; Pile foundation; Liquefaction analysis

Essential Reading:

1. Online manuals of the software used for drawing and design.

CE 474	WATER RESOURCES ENGINEERING DESIGN PRACTICE	2 Credits [0-0-3]

Design of unlined canal using Kennedy's theory; Design of unlined canal using Lacey's theory and comparing the design using Garret's diagram; Economics of canal lining-finding the cost-benefit ratio by lining an unlined canal; Design of a trapezoidal concrete lined canal section; Calculation of balancing depth of cut for a canal section; Draw the phreatic line for a homogeneous earth dam without filter; Draw the phreatic line for an earth dam with horizontal filter and that for a zoned section; Design of a strainer type tube-well; Design of an unflumed, non-metered straight glacis fall

Essential Reading:

2. Water Resource Engineering laboratory manual.

DEPARTMENT OF CHEMICAL ENGINEERING

DETAILED SYLLABI OF COURSES

Sub. Code	Subject	L-T-P	Credits
CH 211	Processing and Handling of Materials	3-0-0	3
CH 212	Fluid Dynamics	3-1-0	4
CH 220	Chemical Engineering Thermodynamics	3-1-0	4
CH 221	Fundamentals of Biochemical Engineering	3-0-0	3.
CH 223	Chemical Process Technology	3-0-0	3
CH 224	Polymer Science and Technology	3-0-0	3
CH 225	Chemical Process Calculations	3-1-0	4
CH 226	Fuels and Combustion	3-0-0	4
CH 227	Fertilizer Technology	3-0-0	3
CH 228	Treatment of Industrial Effluents	3-0-0	3
CH 229	Basic Chemical Engineering	3-0-0	3
CH 270	Materials Handling Laboratory	0-0-3	2
CH 271	Process Technology Laboratory	0-0-3	2
CH 272	Fluid Dynamics Fundamentals Laboratory	0-0-3	2
CH 273	Fuels and Combustion Laboratory	0-0-3	2
CH 311	Heat Transfer Operations	3-1-0	4
CH 312	Transport Phenomena	3-1-0	4
CH 315	Mass Transfer Operations	3-1-0	4
CH 321	Fundamentals of Biochemical Engineering	3-0-0	3
CH 322	Environmental Biotechnology	3-0-0	3
CH 323	Energy Conservation and Renewable sources of Energy	3-0-0	3
CH 324	Particulate Science and Technology	3-0-0	3
CH 329	Process Plant Safety	3-0-0	3
CH 330	Petroleum Refinery Engineering and Petrochemicals	3-0-0	3
CH 331	Polymer Science and Technology	3-0-0	3
CH 334	Process Dynamics and Control	3-1-0	4
CH 335	Applied Statistics for Chemical Engineers	3-0-0	3
CH 336	Chemical Engineering Mathematics	3-1-0	4
CH 337	Equipment Design (Mech. Aspects)	3-1-0	4
CH 338	Industrial Instrumentation and Process Control	3-0-0	3
CH 370	Computer Aided Design Laboratory – I	0-0-3	2
CH 371	Heat Transfer Fundamentals Laboratory	0-0-3	2
CH 372	Heat Transfer Design Laboratory	0-0-3	2
CH 373	Mass Transfer Fundamentals Laboratory	0-0-3	2
CH 374	Mass Transfer Design Laboratory	0-0-3	2
CH 375	Biotechnology Laboratory	0-0-3	2
CH 376	Process Instrumentation Laboratory	0-0-3	2
CH 377	Fluid Dynamics Applications Laboratory	0-0-3	2
CH 414	Nanotechnology in Catalysis	3-0-0	3

CH 415	Fluidization Engineering	3-1-0	4
CH 417	Modern Separation Processes in Chemical Engineering	3-0-0	3
CH 418	Recent Separation Technologies	3-0-0	3
CH 419	Computational Fluid Dynamics	3-1-0	4
CH 421	Reaction Kinetics and Catalysis	3-1-0	4
CH 422	Simulation, Modeling and Optimisation of Chemical Process	3-1-0	4
CH 425	Environmental Engineering	3-0-0	3
CH 426	Coal Processing Technology	3-0-0	3
CH 427	Colloid and Interfacial Engineering	3-0-0	3
CH 428	Disaster Management in Chemical Industries	3-0-0	3
CH 432	Optimization Techniques in Process Design	3-0-0	3
CH 434	Project Engineering	3-0-0	3
CH 439	Non-Traditional Optimization Techniques	3-0-0	3
CH 470	Process Simulation Laboratory	0-0-3	2
CH 471	Chemical Reaction Engg. Laboratory	0-0-3	2
CH 473	Computer Aided Design Laboratory – II	0-0-3	2
CH 475	Process Dynamics and Control Laboratory	0-0-3	2

For B. Tech. Courses (3 or 4 level) please refer to the B. Tech. Curriculum and Syllabi, for M. Tech Courses (6 level) please refer to M. Tech Curriculum and Syllabi.

CH 211 PROCESSING AND HANDLING OF MATERIAL 3 credits [3-0-0]

Characteristics of a single particle: Size, shape, surface area, volume, Properties of solids.; Characteristics of a collection of particles: Particle Size Distribution: Specific surface of mixture, average particle size, Number of particles, Screen analysis: Effectiveness of screen, Industrial screening equipments, Size reduction: Factors affecting comminution, Laws of comminution, Industrial equipments; Particle Dynamics: Single Particle: Settling velocity, Effect of shape, Wall effect, Mixture of Particles: hindered settling; Separation of particles: Solid-solid separation: Classification, Jigging, Magnetic and Electrostatic separations, Liquid-solid separation: Sedimentation, Filtration, Hydro-Cyclones, Gas-solid separation: Flotation; Mixing and Agitation: Phenomena of mixing and agitation, Circulation, velocities and power consumption in agitated vessels, Solid-liquid mixing, solid-solid mixing; Particle transport and storage: Storage of solids: Hopper, Bins & Silos, Mechanical conveyers, Gas-solid: Pneumatic transport in horizontal and vertical pipelines, Liquid-solid: Hydraulic transport Beneficiation circuits of Minerals: Chalcopyrites, Sphalerites, Galena and Bauxite.

Essential Reading:

1. C. M. Narayanan & B. C. Bhattacharyya, ***Mechanical Operation for Chemical Engineers (Incorporating Computer Aided Analysis)***, Khanna Publisher, Third Edition, 2005.
2. W I McCabe & J C Smith, P. Harriot, ***Unit Operations of Chemical Engineering,*** McGraw-Hill publication, 2005

Suggested Reading:

1. M. C. Fuerstenau and K. N. Han, ***Principles of Mineral Processing,*** John Wiley, N. Y, 2003
2. J. F. Richardson, J. H. Harker & J. Backhurst, ***Chemical Engineering Volume 2***, Butterworth-Heinemann, 1st edn, 2002.

CH 212 FLUID DYNAMICS 4 credits [3-1-0]

Fluid mechanics: Nature of fluid, Pressure concept & various pressure measuring devices.; Fluid dynamics : Fluid flow phenomena, Nature and classification of flow, Dynamic properties of fluid, Boundary layer formation in straight tube, Universal velocity profile, Haugon and Poiseulle equation, Measurement of viscosity, Dimensional analysis applied to fluid flow problems, Buckingham's theorem, Physical significance of Reynold's number.; Transportation of fluids: Bernoulli's equation for friction less flow and correction for frictional flow; Pumps: Types, Selection, Applications, Performance characteristics of centrifugal and reciprocating pumps; Flow past immersed bodies: Flow through packed beds, kozney Carman equation, Filtration and Centrifugation, Motion of particles through fluids, Terminal settling velocity, Hydraulic and Pneumatic classification; Fluidization: Types of fluidization, Prediction of minimum fluidization velocity and bed pressure drop, bubbling, slugging and distributors; Introduction to Non-Newtonian fluids.

Essential Reading:

1. W. L. McCabe, J. C. Smith, P. Harriot, ***Unit Operations of Chemical Engineering***, McGraw-Hill Publication, 2005.

Suggested Reading:

1. G. K. Batchelor, ***Introduction to Fluid Dynamics,*** Oxford University Press, 2000.
2. Pre-requisite: Knowledge in under graduate "Fluid Mechanics"

CH 220	CHEMICAL ENGINEERING THERMODYNAMICS	4 credits [3-1-0]

First law: Evaluation of PVT properties of fluids, Law of corresponding states, Residual volume, Compressibility factor, Equations of state; Heat effect – Clausious Clepeyren equation; Second law: Entropy, Work function, Free energy; Phase rule: Theoretical and experimental aspects of phase rule and its use in study of multi-component system; Refrigeration: Thermodynamic efficiency, production of work from heat. Partial molal properties, Chemical potential, Fugacity. Gibbs-Duhem equation. Determination of activity coefficients from van Laar equation; Chemical reaction equilibria, Introduction to third law.; VLE and LLE calculations.

Essential Reading:

1. J. M. Smith & H. C. V Ness and M. M. Abbot, ***Introduction to Chemical Engineering Thermodynamics***, Mc Graw and Hills Publication***, 2005***

Suggested Reading:

1. K. Denbigh, ***The principles of Chemical equilibria with applications in Chemistry and Chemical Engineering***, 1981
2. S. I. Sandler, ***Chemical and Engineering Thermodynamics***. John Wiley publication, 3rd edition, 2003

CH 223	CHEMICAL PROCESS TECHNOLOGY	3 credits [3-0-0]

Introduction of CPT with reference to Indian resources, industries, trade and export potential, small scale industries and rural development. Preparation of process flow diagrams, Instrumentation diagrams and Process symbols.; Introduction to the following industries lying emphasis on process flow sheet, material requirements, process conditions, material of construction and design aspects.

Chlor-Alkali Industries: Manufacture of Soda ash, Caustic soda and Chlorine.

Acids; Manufacture of Sulphuric acid, Hydrochloric acid and Nitric acid.

Electro thermal Industries: Manufacture of Silicon Carbide and Calcium Carbide.

Extraction and Refining of edible oil, Fat splitting and Hydrogenation of oil.

Soaps and Detergents, recovery of Glycerin.

Production of Pulp, Paper and Rayon.

Fermentation Industries: Manufacture of Industrial alcohol, Absolute alcohol and allied products.

Manufacture of Sugar, Starch and its derivatives.

Coal based Chemical Industries.

Essential Reading:

1. C. E. Dryden, ***Dryden's outlines of Chemical Technology for the 21st century***, (Edited & revised by M. G. Rao and M Sitting) 2006
2. G. T. Austin, ***Shreve's Chemical Process Industries***, 5th edition, McGraw Hill Book Co., New York, 1984

Supplementary Reading:

1. S. D. Shukla & G. N. Pandey, ***A Text Book of Chemical Technology, Vol. II,*** Sangam Books***, 2000.***
2. W. V. Mark edited by S. C. Bhatia, ***Chemical Process Industries Vol. I & Vol. II*** 2nd edition, CBS Publisher and Distributor, 2007.
3. R. E. Kirk and D. F. Othmer, ***Encyclopedia of Chemical Technology***, 4th edition, Interscience, New York, 1991 (In our library).

CH 224	POLYMER SCIENCE AND TECHNOLOGY	3 credits [3-0-0]

Historical Background, Classification and forms of Polymers, Tacticity, Functionality, Degree of Polymerization, identification of Polymers and end uses; Chemistry of Polymerization: Chain and Step Polymerization and their Kinetics Techniques of Polymerization: Bulk, Solution, Suspension and Emulsion Polymerization; Molecular Weight and its determination by Viscometry, Light-scattering and Osmometric methods; Crystallization in Polymers; Polymer Degradation; Manufacture and Uses of PF, UF, Vinyl Resins, Acrylic Resins, PS and PE; Polymer additives, Blends and Alloys; Polymer Processing; Plastics as materials of construction in chemical equipments.

Essential Reading:

1. R. Mann, ***Introductory Polymer Science***, Dhanpat Rai Publications.

Suggested Reading:

1. S. K. Bhasin and J. R. Fried, ***Polymer Science and Technology***, Prentice-Hall.
2. F. W. Billmeyer, ***Textbook of Polymer Science***, John Willey & Sons
3. R. Sinha, ***Outlines of Polymer Technology-I, II***, Prentice-Hall.
4. Pre-requisite: Knowledge in under graduate "Basic chemistry"

CH 225	CHEMICAL PROCESS CALCULATIONS	4 credits [3-1-0]

Chemical reactions: Excess reactant, Degree of completion, Composition of mixtures and solutions; Material balance: Calculations for (a) unit operations like mixing evaporation, crystallization and distillation, (b) Chemical reactions and (c) Recycling; Behaviour of ideal gases: Various equations of state, Law of Dalton and Amagat, Densities of gaseous mixture.; Vapour pressures: Liquefaction, Vaporisation, Boiling point, Vapour pressures of solids and liquids, Roult's law, Polar and non-polar compounds; Energy balance: Heat capacity of gases, liquids, solids and solutions, Kopp's rule, Heats of fusion and vaporisation, Trouton's rule and Kistia Kowaky equation, calculation of heat of reaction, combustion, formation and neutralisation, enthalpy concentration charts, Flame temperatures; Material and energy balance in industrial processes: Simple material and energy balance calculations for the following manufacturing processes – (a) Sulphuric acid, (b) Nitric acid, (c) Phosphoric acid, (d) Lime and Alkali; Numerical techniques for solving material and energy balance equations; Vapour – liquid equilibrium calculations.

Essential Reading:

1. O. A. Hougen et. al, ***Chemical Process Principles (Vol. 1).***
2. R. M. Felder and R. W. Rousseau, ***Elementary Principles of Chemical processes***, John Wiley, 2004

Suggested Reading:

1. R. K. Dave, ***Chemical Reactions and Stoichiometry,*** Campus books International***, 2000***
2. M. Sylvin, ***Problems in stoichiometry,*** Sarup & Sons, 2003
3. Pre-requisite: Knowledge in under graduate "Basic chemistry & Mathematics"

CH 226	FUELS AND COMBUSTION	4 credits [3-1-0]

Solid fuels: Coal origin, Chemical composition, Calorific value, Classifications, Characteristics and Distribution of Indian coals, Storage and spontaneous combustion of coal, Coal washing and blending, Petographic constituents of coal, Carbonization of coal, Manufacture and properties of metallurgical coke, Recovery of byproducts; Liquid fuels: Origin and composition of crude oil, Crude oil distillation and it's products with special reference to gasoline, kerosene and diesel oil, Cracking and reforming, Shale oil; Gaseous fuels: Natural gas, Coal gas, Coke oven and blast furnace gas, Manufacture of water gas and producer gas, Carbureted water gas; Synthetic fuels: Hydrogenation of coal, Fischer – Tropsch synthesis; Combustion: Combustion of solid, liquid and gaseous fuels, combustion stoichiometry and thermodynamics, Calculation of volumes and weights of air required for combustion, the gas analysis.

Essential Reading:

1. S. Sarkar, ***Fuels and Combustion***. 3rdEdn., Universities Press (India) Pvt. Ltd.
2. S. N. Saha, ***Fuel Combustion Energy Technology***, Dhanpat Rai Pub. Co.

Suggested Reading:

1. Himus, ***Elements of Fuel technology.***
2. J. Brame and King, ***Fuels: Solid, liquid and gaseous fuels,*** Kessinger Publishing, LLC, 2007.
3. O. P. Gupta, ***Elements of Fuels, Furnaces and Refractories.***

CH 227	FERTILIZER TECHNOLOGY	3 credits [3-0-0]

Fertilizers: Chemical fertilizers, Types of chemical fertilizers, Fertilizer applications and agronomical details; Nitrogenous fertilizers: Feedstock for production of Ammonia gas, Associated gas, Coke oven gas, Naphtha, Fuel oil, Petroleum heavy stock, Coal, Lignite, Water, Coke, methods of production, Characteristics, Specification and storage of ammonium sulphate, nitrate, urea, calcium ammonium nitrate and ammonium chloride; Phosphatic fertilizers: Raw materials – Phosphate rock, Sulphur, Pyrirites. Methods of production, Characteristics, Specification and storage of single super phosphate, triple super phosphate; Potassic fertilizers: Methods of production, Characteristics, Specification and storage of potassium chloride, potassium sulphate and potassium schoenite; Complex and NPK fertilizers: Methods of production, Characteristics, Specification and storage of ammonium phosphate sulphate, Diammonium phosphate, Nitrophosphates, Urea ammonium phosphate, Mono ammonium phosphate and various grades of NPK fertilizers; Others: Secondary nutrients, Micro nutrients, Fluid fertilizers, Controlled release fertilizers; Technology of compound fertilizers, Nitrogeneous fertilizers, Phosphate fertilizers, Potash and mixed fertilizers, Fertilizer applications and agronomical details, Technology of ammonia manufacture, Fertilizer raw materials and availability.

Essential Reading:

Supplementary Reading:

1. Nielssion, ***Manual for Fertilizer Technology Series***
2. S. Lee, J. G. Speight, and S. K. Loyalka, ***Handbook of Alternative Fuel Technology,*** CRC, 2007

CH 228	TREATMENT OF INDUSTRIAL EFFLUENTS	3 credits [3-0-0]

Characterisation of waste waters - quality of various industrial effluents; permissible limits; Fundamentals of waste water treatment technologies; water treatment equipments; Biological waste water treatment: - completely mixed aerated lagoons, oxidation ditches and waste stabilisation ponds - activated sludge - microbial community in activated sludge - aerobic digestion, trickling filters - rotating biological contactors - nitrification - biological fluidised bed reactors for treatment of sewage and industrial effluents - anaerobic digestion and anaerobic contact process - denitrification - fluidised bed anaerobic reactors - anaerobic down flow stationary fixed film reactors.; Case studies of waste water treatment and disposal of tannery-dye factory-sugar industry-paper and pulp industry -viscose industry - agro chemical industries- fertilizer industries - petro chemical industry and pharmaceutical industries.; Treatment of gaseous pollutants: Ambient air sampling, analysis methods and measuring devices; air pollution standards, air pollution control equipments; Case studies of gaseous effluent treatment in typical industries: steel plants, power plants etc.

Essential Reading:

1. N. W. Jern, ***Industrial waste water Treatment***, Imperial College Press, 2006.

Suggested Reading:

1. R. S. Ramalho. 1983. ***Introduction to Waste Water Treatment Process***. Academic press. New York.
2. S. D. Lin and C. C. Lee, ***Waterand Waste Water Calculation Manual,*** McGraw-Hill, 2001.

CH 229	BASIC CHEMICAL ENGINEERING	3 credits [3-0-0]

Introduction: Units and dimensions, basic laws, unit operations and unit processes; Physico-chemical calculations: Material and energy balance for different unit operations; nit processes.; Fluid flow and flow measurement: Nature of fluid, viscosity, friction factor, flow through; porous media, fluidization, flow measuring devices; Heat transfer: Modes of heat transfer, calculation of heat transfer coefficient, heat exchangers and evaporators.; Mass transfer: Transfer mechanism, mass transfer coefficient, introduction to mass transfer operations viz. gas absorption, distillation, leaching and drying, stage and continuous contactors.; Chemical kinetics: Rate equation, catalysis, tyre of reactors; Natural resources and their utilization: Important chemical industries based on natural resources viz. paper (wood), soap and detergents(oil seeds), cement(minerals), fertilizers; (water, coal and minerals)and petroleum refinery(crude oil).; Chemical process instrumentation: Elements of instruments, static and dynamic characteristics, dynamic response of process instruments, recording, indicating and signaling instruments.; Pollution from chemical industries and its abatement: Solid, liquid and gaseous effluents from chemical industries and their abatement.

Essential Reading:

1. W. L. McCabe, J. C. Smith and P. Harriott, ***Unit Operations of chemical Engineering***, McGraw-Hill, Inc**.,** Sixth Edition, 2005

Suggested Reading:

1. J. M. Coulson, J. F. Richardson, J. R. Backhurst and J. H. Harker, ***Chemical Engineering***, ***Vol. 1 and 2,*** Pergamon Press, Fourth Edition, 1990.
2. G. T. Austin, ***Shreve's Chemical Process Industries***, McGraw Hill Book Co., Fifth Edition, (Latest)

CH 270	MATERIAL HANDLING LABORATORY	2 credits [0-0-3]

Determination of average particle size of a mixture of particles by sieve analysis.; Study and operation of Jaw crusher and thereby verification of Ritinger's constant; Determination of reduction ratio, maximum feed size and theoretical capacity of crushing rolls; Determination of the effect of no. of balls on grinding in a Ball mill and comparison of its critical speed with the operating speed; To find out the effect of time on grinding and amount of undersize at zero time of grinding in a ball mill and to compare its operating speed with the critical speed; To find out enrichment of the coal sample using a froth flotation cell; Determination of the effectiveness of a vibrating screen; To find the efficiency of Wilfley Table and the effect of water flow rate on efficiency of separation; Study and operation of a Hammer mill thereby finding its reduction ratio; Study and operation of a Pulverizer and thereby finding its reduction ratio; Study and operation of a cyclone separator and thereby finding its efficiency of separation; Study and operation of a Magnetic separator and thereby finding its efficiency of separation; Study and operation of a Gyratory Crusher and thereby finding its reduction ratio.

CH 271	PROCESS TECHNOLOGY LABORATORY	2 credits [0-0-3]

Preparation of soap from oil and Determination of alkali content in the soap: Commercial soap; Prepared soap. Determination of saponification value of oil; Determination of fat content in the food stuff using Soxhlet apparatus; Preparation of activated carbon; Determination of Total organic carbon in the water sample; Determination of surface area using BET apparatus; Determination of Bromine no of oil sample; Distribution Coefficient determination for iodine in organic solvent and water; Determination of iron content in a given salt solution; Determination of lime% in a Portland cement; Determination of COD in the water sample; Determination of dye concentrates using spectrophotometric analysis.

CH 272	FLUID DYNAMICS FUNDAMENTAL LABORATORY	2 credits [0-0-3]

To find the cake and filter medium resistance of Plate and Frame Filter press; To find the filter medium resistance of a Vacuum Leaf Filters; To find the flow rate using a V notch; To find the friction losses in a Straight pipe; To find the friction losses in a Bend pipe; Study of Pipe fittings and Valves; To study the principle of a hydro-cyclone and find out the efficiency of separation; To study the Reynold's apparatus and verify experimentally; To study the working principle of a reciprocating pump and to determine the percentage of slip; To study the working principle of a centrifugal pump and determine its efficiency experimentally; To determine the cake resistance of a batch basket centrifuge; To find out the flow profile of water from hook's gauge and determination of coefficient of velocity, coefficient of discharge, coefficient of resistance, coefficient of contraction.

CH 273	FUELS AND COMBUSTION LABORATORY	2 credits [0-0-3]

Determination of composition of the supplied sample of Coal by Proximate Analysis; Determination of Caking Index of the supplied sample of Coal by Grey – campredon method; To determine the washability characteristics of the supplied sample of Coal using Float and Sink test; To find the effect of temperature on viscosity of the supplied samples of liquid fuel using Red wood viscometer; To find the effect of temperature on viscosity of the supplied samples of lubricating oil using Engler's viscometer; To find the Flash and Fire point of the supplied samples of liquid fuel using: Penslery Martein closed cup apparatus; Abel open cup apparatus; To find the Aniline point of the supplied samples of liquid fuels using Aniline point apparatus and hence find out the Diesel Index Number of the Diesel oil; To find the Carbon Residue of the supplied sample of lubricating oil / oil mixture using Conradson apparatus; To find the moisture content of the supplied samples of liquid fuel / Crude oil using Dean and Stark apparatus; To find the Pour point and Solidfication point of the supplied samples of liquid fuels; To find the Calorific value of LPG using: Boy. s Gas calorimeter, Junker's Gas calorimeter; To find the composition of the gas using Gas Chromatograph and hence determine the percent of excess air used for combustion of the fuel used; To determine the ultimate analysis of the supplied sample of coal and hence find the theoretical GCU of given coal; To determine the Swelling Index of the supplied sample of coal and ascertain the agglomerating characteristics of the coal sample; To determine the Gross calorific value of the supplied sample of coal using Bomb Calorimeter (on ash free basis); To determine the Smoke Point of kerosene oil using Smoke Point Apparatus.

CH 311	HEAT TRANSFER OPERATIONS	4 credits [3-1-0]

Mechanism of heat transfer: Conduction – Fourier's law, Steady state conduction of heat through plane, cylindrical and Spherical solids - single and in series. Convection – Steady state heating and cooling of fluids without phase change, Heat transfer from condensing vapours and to boiling liquids – filmwise and dropwise condensation, boiling coefficients. Radiation – Kirchhoff's law, Stefan-Boltzman law, Simple case of radiation heat transfer between surfaces; Applications of heat transfer: Evaporation – Effect of liquid characteristics, Single and multi-effect evaporation, Types of evaporation and their attachments, Performance of single effect evaporation, Boiling point rise, Multiple effect evaporation – forward, backward, mixed and parallel feed, Performance of multiple effect evaporation in comparison to that of single effect evaporation, Vapour compression evaporation, Calculations for single effect evaporators; Different types of Heat Exchangers; Heat transfer augmentation.

Essential Reading:

1. D. Q. Kern, ***Process Heat Transfer,*** Mc Graw & Hills, 1982
2. F. P. Incropera, ***Fundamentals of Heat and Mass Transfer,*** John Wiley & Sons, 2007

Suggested Reading:

1. W. L. McCabe and J. C. Smith, ***Unit Operations of Chemical Engineering***, Mc Graw & Hills, 2005.
2. R. W. Serth, ***Process Heat Transfer: Principle and Applications***, Academic press, 2007.

CH 312	**TRANSPORT PHENOMENA**	**4 credits [3-1-0]**

Momentum transport: Viscosity and mechanism, Newton's law and viscosity, Non-Newtonian fluids, Temperature and pressure dependence of viscosity (gases at low density); Velocity distributions in laminar flow, Shell momentum balances, Flow of falling film, Flow through circular tube and annulus as adjacent flow of two immiscible fluids and creeping flow around a solid sphere, Equations of changes for isothermal system (compressible), Unsteady state viscous flow, Interphase transportations in isothermal system, Friction factor; Energy transport: Thermal conductivity in solids, Fouriors law of heat conduction, Temperature and heat dependence of thermal conductivity in gases and liquids; Temperature distributions in solids and in laminar flow, Shell energy balances, Heat conduction with electrical, viscous and chemical sources, Heat conduction through composite walls and in cooling fin forced and free convection; Equations of change for non-isothermal systems, Equations for energy in rectangular coordinates. Unsteady state heat conduction in solids; Mass transport: Diffusivity and mechanism, Temperature and pressure dependence of mass diffusivity; Concentration distributions in solids and in laminar flow, Shell mass balances, diffusion through a stagnate gas film, Diffusion with homogeneous and heterogeneous chemical reactions, diffusion into a falling liquid film, Diffusion and chemical reaction inside a porous catalyst. Equations of continuity for a binary mixture in rectangular coordinates; Inter-phase transport in multi-component system, Definition of binary mass transfer coefficients in one phase, Correlations of binary mass transfer coefficients in one phase at low mass transfer coefficients and in two phase at low and high mass transfer rates.

Essential Reading:

1. R. B. Bird, W. E. Stewart, and E. N. Lightfoot ***Transport phenomena***, John Wiley & Sons; Revised 2nd Edition edition, 2007

Suggested Reading:

1. Bennett and Myers, ***Mass, Heat and Momentum transport***.
2. J. Welty, C. E. Wicks, G. L. Rorrer, and R. E. Wilson ***Fundamentals of Momentum Heat and Mass Transfer***, John Wiley & Sons; 5th Edition edition, 2008
3. R. S. Brodkey & H. C. Hershey, ***Transport Phenomena***.
4. Pre-requisite: Knowledge in under graduate "Basics of Heat & Mass transfer & Fluid Dynamics"

CH 315	**MASS TRANSFER OPERATIONS**	**4 credits [3-1-0]**

Mechanism of Transfer; Diffusion in gases and liquids. Analogy between mass momentum and heat transfer, Theories of Interphase Mass transfer, Coefficients and their correlations; Gas – Liquid Operations; Absorption: Choice of packings & solvent, M. I. R., N. T. U., H. T. U. and H. E. T. P. : calculation of height and diameter for packed towers.; Distillation: Boiling point diagram, Flash, Differential, vacuum steam, azcotropic and extractive distillation, Rectification and stripping, calculation of number of ideal stages by McCabeThiele and Ponchan - Savarit methods; Liquid – liquid operation; Extraction: batch and continuous, calculation of number of ideal stages, multistage extraction, equipment and their design principles; Gas – Solid Operation; Humidification and Drying: Wet and dry bulb hygrometry, spray chamber, cooling towers. Theory, mechanism and rate of drying, design and working principles a few types of dryers viz. shelf dryer, drum dryer, rotary dryer and fluidized bed dryer; Crystallization: Theory and applications, Various types of crystallizers

Essential Reading:

1. R. E. Treybal, ***Mass Transfer Operations***, Mc Graw and Hills, 1980.
2. W. L. McCabe & J. C. Smith, ***Unit Operation of Chemical Engineering***, Mc Graw & Hills, 2005.
3. B. K. Dutta, ***Principles of Mass Transfer and Separation Processes,*** Prentice Hall, 2005.

Suggested Reading:

1. T. K. Sherwood and R. L. Pigford, ***Absorption and Extraction.***
2. V. Winkle; ***Distillation***.
3. Sherwood, Pigford and Wilke; ***Mass Transfer***.
4. J. Benitez, ***Principle and Modern Application of Mass Transfer Operation***, Wieley and Interscience, 2002
5. A. F. Mills, ***Mass Transfer***, Prentice Hall, 2001

CH 321 FUNDAMENTALS OF BIOCHEMICAL ENGINEERING 3 credits [3-0-0]

Introduction to Microbiology: Structure of cells, types of cells; Introduction to Biochemical process industries: Industrial alcohols, anti biotic, enzymes, vitamins, single cell process; Fermentation mechanisms and kinetics: Kinetic models of microbial growth and product formation; Fermention types: Batch and continuous fermentation; Bioreactors: Types of bioreactor and design; Sterilization; Sterilization of media and air, equipment, batch and continuous sterilizer design; Biochemical product separation and recovery: Membrane separation process, chromatographic method; Application to waste water treatment: Activated sludge process, aerobic and anaerobic processes.

Essential Reading:

1. G. Najafpour, ***Biochemical Engineering & Biotechnology***, Elsivier Science, 2006.
2. J E Bailey and D F Ollis; ***Biochemical Engineering Fundamentals,*** Mc Graw & Hills Publication***, 1986.***

Suggested Reading:

1. M. L. Shuler and F. Kargi, ***Bioprocess Engineering: Basic Concepts,*** Prentice Hall of India, 2001.
2. R. Dutta, ***Fundamentals of Biochemical Engineering***, Springer, 2008.

CH 322 ENVIRONMENTAL BIOTECHNOLOGY 3 credits [3-0-0]

General effluent treatment – nature of sewers, sewage; Methods adopted in effluent treatment; Legal Consideration – Royal Commissions. Current situation in laying of charging ownership, regulations, legislation; Activated sludge process equipment, plant kinetics, CSTR modeling. PFR modeling, recycle stability, washout; Advanced Process – Trickling fitter, moving medium system; Biology of effluent treatment process: Roles of bacteria, fungi and protozoa. Extracellular Polymers, films, flocs, Analysis of effluent; Nutrition, Carbon removal, influences of loading ratio, retention times, season on kinetics and performance, Nitrogen and Phosphorous requirement for adequate plant performance. Nitrification and De-nitrification Anoxic process, extended aeration, high rate process; Sludge disposal methods; Anaerobic processes. Sludge digestion (contact digester), Management of digester sludge. Aerobic effluent treatment. Gas production and utilization, related problem.

Essential Reading:

1. M. J. Waites, N. L. Morgan, J. S. Rockey, and G. Higton, ***Industrial Microbiology,*** Wiley Blackwel, 2001.

Suggested Reading:

1. W. Grueger and A. Crueger, ***Biotechnology a Text book of Industrial Microbiology***, Mc Graw Hill, 1990.
2. J. E. Bailey and D. F. Ollis, ***Biochemical Engineering Fundamentals***, Mc Graw-Hill, 2005.

CH 323 ENERGY CONSERVATION & RENEWABLE SOURCES OF ENERGY 3 credits [3-0-0]

Introduction to Energy Science and Energy Technology; Energy Science and Energy Technology, world energy future, Energy sources and their availability. Renewable energy sources. Prospects of Renewable energy sources; Solar energy fundamentals and application; Geothermal energy: Introduction, Utilization of Geothermal energy, Geothermal energy resources, geothermal gradient, Different types of Geothermal Electric power plant and their operations for Geothermal Energy systems in India; Wind energy: Fundamentals and application, Basic principles of Wind Energy Conversion, Wind Energy conversion system, Performance of wind machines, Electric generation for wind; Biomass Energy Resources: Introduction, Biomass Conversion Process. Biogas from plant wastes, communities bio-gas plants. Biochemical conversion, Fermentation, liquid fuels for biomass; Urban Waste: A source of Energy. Urban solid waste, waste incineration process. Environmental consideration, Fluidized bed combustion boilers for burning solid waste and fossil fuels; Energy from the oceans: Introduction Ocean Energy conversion Technologies. Types of Ocean Thermal Electric Power Generation system and their operation. Tidal power plant; Hydro Energy: Introduction, types hydro-electric plants and energy conversion scheme, Impulse turbine and Reaction turbine. Classification of Hydro-Energy plants; Energy Conservation: Principle of energy conservation and Energy Audit. Energy conservation Technologies. Co-generation, waste heat utilization, Heat recuperates, Heat regenerators, Heat pipes, Heat pumps, Energy storage.

Essential Reading:

1. S. Rao and Dr. B. B. Parulekar, ***Energy Technology, Non convential, Renewable and Conventional***, Khanna Publishers.

Suggested Reading:

1. G. D. Rai, ***Non-conventional Energy Sources***, Khanna Publishers.
2. D. S. Chauhan and S. K. Srivastava, ***Non- Conventional Energy Resources***, New Age International Pvt Ltd.
3. G. N. Tiwari, ***Fundamentals of Renewable Energy Sources***, Narosa Publishing House.

CH 324 PARTICULATE SCIENCE & TECHNOLOGY 3 credits [3-0-0]

Study of particles: Definition of a particle, Qualities of particles; The industrial revolutions: explosion of particle related advances (from advanced mining techniques to abrasives, cutting tools, and mass production of chemicals and agricultural products). Modern scientific advances in paints and coatings and other particles in various base solvents, Particles in fluids.; Composite materials, the design and manipulation of matter on the nanoscale and into nanostructures.; Particle Science as an enabling technology to create new energy sources, clean our air and water and build stronger and lighter materials. Advances in particle sciences in particular in the area of human healthcare.

Essential Readings:

1. J. K. Beddow, ***Particulate Science and Technology.***
2. R. B. Bird, W. E. Stewart, and E. N. Lightfoot ***Transport phenomena***, John Wiley & Sons; Revised 2nd Edition Edition, 2007
3. M. Leva, ***Fluidization***.

CH 330 PETROLEUM REFINERY ENGINEERING AND PETROCHEMICALS 3 credits [3-0-0]

Origin of Petroleum: Mendeleev and Englers' theories, Composition of petroleum, Indian oil fields, Composition of Indian crudes, Properties of crude and products; Evaluation of oil stocks: Base of crude oil, Characterisation factor – TBP apparatus, Gravity and mid-percent curve, Yield curve, Equilibrium flash vaporisation curve, ASTM distillation characteristics of products, ASTM end points and TBP cut point; Crude oil processing: Desalting and dehydration of crude, Tropping, Atmospheric and vacuum distillation; Cracking and Reforming: Important cracking and reforming reactions, Thermal cracking, Fixed bed, Moving bed and Fluidized bed catalytic cracking, Catalytic reforming, Processes like Polyforming and hydroforming; Conversion of petroleum gases into motor fuels with special references to Alkylation, Polymerisation and Isomerisation; Chemical treatment: Sulphuric acid treatment, Sweetening treatment like Solutizer process, Doctor's treatment and Catalytic desulphurization; Solvent extraction: Selection of solvents, Eldeleanu process, Furfural processes; Characteristics of important products like gasoline, kerosene, diesel, jet fuels and lubricating oils.

Essential Reading:

1. W. L. Nelson, ***Petroleum Refinery Engineering***.

Suggested Reading:

1. J. H. Gary, H. Hanwerk and M. J. Kaiser, ***Petroleum Refining Technology and Economics, CRC***, 2007
2. R. J. Hengstebeck, ***Petroleum Processing***.
3. B. Rao, ***Petroleum Refinery Engineering.***

CH 331 PROCESS INSTRUMENTATION 3 credits [3-0-0]

Basic principles: Elements of instruments, Static characteristics, Dynamic characteristics, Applications of Laplace transforms in instruments, Responses of first & second order instruments and capacitance; Temperature measuring instruments like Bimetallic, Vapour pressure, Thermocouples, Automatic Potential Recorders, Resistance thermometers, Radiation pyrometers, Optical Pyrometers, Photo-electric Pyrometers, Thermistors, Responses of these instruments; Composition measuring instruments: Spectroscopic methods, Thermal conductivity cells, Carbon dioxide analyser, Humidity measurement, Moisture in paper and lumber, pH meter, Oxygen analyser, polarograph, Refractometer, Chromatography, Colorimetry, Combustible gas analysers; Measurement of pressure and vacuum: Manometers, Pressure spring, McLeod gauge, Pirani Gauge, Ionization Gauge, Thermocouple Gauge, Responses of these instruments; Measurement of flow properties: Viscosity and specific gravity measurement, Level measuring devices, Flow measuring devices, measurement of displacement; Biosensors and its applications; Process instrumentation diagram, Circular chart, Strip chart recorders, Electric transmission, Pneumatic transmission with examples, Basic idea of automatic control and Instrumentation diagrams for equipments like distillation coloumns, evaporators, crystallisers, dryers and chemical reactors.

Essential Reading:

1. K. Krishnaswamy, ***Industrial Instrumentation***, New Age Publishers, 2003

Suggested Readings:

1. A. Suryanarayana, ***Outline of Chemical Instrumentation and Process Control***, Khanna Publisher, 1995, upcoming ed. 2008
2. J. Curtis, ***Process Control Instrumentation Technology***, Prentice-Hall of India, 2005.
3. R. S. Sirohi, H. C. Radha Krishna, ***Mechanical Measurements***, New Age Publishers, 1991.
4. N. A. Anderson, ***Instrumentation for Process Measurement and Control,*** CRC Press, 1997.
5. W. Dunn, ***Fundamentals of Industrial instrumentation and control system***, McGraw-Hill Professional, 2005.
6. Pre-requisite: Knowledge in under graduate "Basic electronics & Mathematics"

CH 332 PROCESS EQUIPMENT DESIGN 4 credits [3-1-0]

Detailed process design of the following equipments; Heat exchangers – concentric tube, shell and tube types, Condensers – condenser coolers and superheater condensers for single vapour only, Evaporators – single and multi effects, Absorbers – for binary systems without reactions, Distillation columns – for binary mixtures along with tray hydraulics, Rotary dryers; Multi-component Distillation Column Design.

Essential Reading:

1. D. Q. Kern, ***Process Heat Transfer***.

Suggested Reading:

J. H. Perry, ***Chemical Engineers Handbook***.

R. E. Treybal, ***Mass Transfer Operations***.

CH 334 PROCESS DYNAMICS AND CONTROL 4 credits [3-1-0]

Process modeling, Process variables and process degrees of freedom, writing block diagrams, Signal flow diagrams and their algebra, Process dynamics of simple equipment like heat exchanger, chemical reactors and their transfer function; Linear open loop systems: Analysis of first order systems in series and second order system with respect to liquid level, flow, thermal systems and simple chemical processes, Transportation lag; Linear closed loop system: Feedback control, Closed loop transfer functions, Transient response of simple control system, Cascade control, Ratio control, Feed forward and Adaptive control; Frequency response analysis: Introduction, Control system design. Stability of control systems: Ruth, Nyquist, Milkhalov, Bode and Root locus methods; Optimum controller settings: Ziegler Nicholas methods, Continuous cycling, Damped oscillation and Reaction curve method; Controller instruments: Self operated, Pneumatic, Hydraulic, Simple electronic controllers and their uses in level, temperature control, etc; Control valves: Various types of valves, sizing and characteristics of control valves. Basic idea on state equations and state variables and their use in process control. Digital computer control loops and control works, Application – Z transforms, transmitters, sensors. MIMO systems, Digital control.

Essential Readings:

1. G. Stephenanopoulos, ***Chemical Process Control–An Introduction to Theory & Practice***, Prentice-Hall India, 2002.
2. D. R. Coughanowr, ***Process Systems Analysis and Control***, McGraw-Hill International, 1991, upcoming ed. Oct. 2008.

Suggested Readings:

1. B. B. Wayne, ***Process Control: Modeling, Design, and Simulation***, Prentice-Hall India, 2006.
2. C. A . Smith, A. B. Corripio, ***Principles and Practice of Automatic Process Control***, Wiley, 2005.
3. S. K. Singh, ***Computer Aided Process Control***, Prentice-Hall India, 2004.
4. M. L. Luyben, W. L. Luyben, ***Essentials of Process Control,*** McGraw-Hill, 1996

CH 335 APPLIED STATISTICS FOR CHEMICAL ENGINEERS 3 credits [3-0-0]

Introduction to probability, distributions, moments, statistical inference estimation, variance and regression analysis. Statistical Process Control and Reliability, error analysis, point estimation and confidence intervals, design of experiments, process monitoring based on statistical quality control techniques. Taguchi Approach, Case studies and use of Microsoft Excel.

Essential Readings:

1. R. M. Bethea, B. S. Duran, ***Statistical Methods for Engineers and Scientists***, ***Marcel Dekker***, New York, 3rd Edition, 1995.
2. Z. R. Lazic, ***Design of Experiments in Chemical Engineering: A Practical Guide***, ISBN: 978-3-527-31142-2**,** Wiley Publisher, 2005.

Pre-requisite: Knowledge in under graduate "Mathematics"

CH 336 CHEMICAL ENGINEERING MATHEMATICS 4 credits [3-1-0]

Treatment of engineering data: Numerical integration (Simpson, Trapezoidal and Gauss methods), Interpolation (Newton, Lagrange, Stirling), Empirical equations and least squares; Ordinary differential equations: Formulation of the physical problems for mass, energy, rate equations and flow systems. Solutions using analytical and numerical methods; Partial differential equations: Formulation of chemical engineering problems, Coordinate transformation, Solutions of partial differential equations using separation variable method and Fourior series and limited to two dimensional cases; Laplace transforms: Applications to Laplace transforms to simple chem. engg. problems.

Essential Reading:

1. H. S. Mickley, T. S. Sherwood, C. E. Reid, ***Applied Mathematics in Chemical Engg***.

Suggested Reading:

1. V. G. Jenson and G. V. Jeffrey, ***Mathematical Methods in Chemical Engg***.
2. S. Pushpavanam, ***Mathematical Methods in Chemical Engineering***, Prentice Halls, 2004.
3. Pre-requisite: Knowledge in under graduate "Mathematics"

CH 337	EQUIPMENT DESIGN (MECHANICAL ASPECTS)	4 credits [3-1-0]

Storage tank and pressure vessel: Design of storage tanks, pressure vessels and auxiliaries along with important accessories viz. joints, flanges, heads and nozzles; Supports: Guy wire and saddle supports, Design of bearing plate and anchor bolts; Piping: Various types of pipes and pipe fittings, Pipe supports and expansion joints, Design of pipe line; Materials of construction of process equipments; Introduction to various design codes.

Essential Reading:

1. S. Kenneth and J. N. Harb, ***Introduction to Chemical Process: Fundamentals and Design,*** Mc Graw and Hills, 2005.
2. B. C. Bhattacharya, ***Introduction to Chemical Engineering Process Design***.

Suggested Reading:

1. B. E. Brownell & E M Young, ***Process Equipment Design***.
2. M. V. Joshi, ***Process Equipment Design***.
3. H. C. Hesse and J H Ruston, ***Process Equipment Design***.
4. J. H. Perry, ***Chemical Engineers Handbook***.
5. P. C. Sharma & D. K. Agarwal, ***Machine Design***.
6. Relevant Indian Standard Codes.

Pre-requisite: Knowledge in under graduate "Mechanics"

CH 338	INDUSTRIAL INSTRUMENTATION AND PROCESS CONTROL	3 credits [3-0-0]

Basic principles, Elements of instruments, Static characteristics, Dynamic characteristics, Errors, Laplace transforms, Responses of first & second order instruments and capacitance; Transducers, Temperature measuring instruments and there responses. Composition measuring instruments, Measurement of pressure and vacuum: Instruments and there responses. Measurement of flow properties: Measurement of displacement; Measurement of Head and Level, Biosensors and its applications; Signal conditioning, Transmission, Display and recording devices.; Fundamentals of automatic control, Time delay, Feedback control, Stability (Routh array & root locus), Frequency response analysis (Bode and Nyquist plots), Design of feedback controllers, Digital control.

Essential Reading:

1. A. K. Ghosh, ***Introduction to Instrumentation and Control***, Prentice-Hall of India, 2005.
2. J. Curtis, ***Process Control Instrumentation Technology***, Prentice-Hall of India, 2005

Suggested Readings:

1. K. Krishnaswamy, ***Industrial Instrumentation,*** New Age Publishers***, 2003.***
2. G. Stephenanopoulos, ***Chemical Process Control–An Introduction to Theory & Practice***, Prentice-Hall India, 2002.
3. N. A. Anderson, ***Instrumentation for Process Measurement and Control***, CRC Press, 1997.
4. W. Dunn, ***Fundamentals of Industrial instrumentation and control system,*** McGraw-Hill Professional, 2005.

CH 370	COMPUTER AIDED DESIGN LABORATORY - I	2 credits [0-0-3]

Application of Gauss elimination Technique to solve coupled linear algebraic equations; Application of Newton Raphson Technique to solve coupled non-linear algebraic equations; Finding out the roots of an algebraic equation using "Interval-having"; Integration of ordinary differential equation using "Explicit Euler integration" algorithm; Integration of ordinary differential equation using "Renga-ktta(forth-order)" algorithm; Finding out the Eigen values of a matrix; Finding out the Rank of a matrix; Finding out the Inverse of a matrix; Bubble point calculation using "Interval-having" algorithm. Bubble point calculation using "Newton-Raphson" Technique; Parameter estimation using least-square technique.

Note: The aforesaid problems have to be solved by writing codes in 'C' language.

CH 371 HEAT TRANSFER FUNDAMENTAL LABORATORY 2 credits [0-0-3]

To find out the thermal conductivity of liquids; To find out the thermal conductivity of a metal rod; Find out the Heat Transfer Coefficient during drop wise and film wise condensation; Find out the Heat Transfer Coefficient in a vertical and a horizontal condenser; To find out the emissivity of a surface; To find out the overall thermal conductance and plot the temperature distribution in case of a composite wall; To find out the average heat transfer co-efficient of vertical cylinder in natural convection; To find out the Stefan Boltzman's constant and compare with the theoretical value; To find out the relation between insulation thickness and heat loss; To find out the overall heat transfer co-efficient of a double pipe heat exchanger; To find out the overall heat transfer co-efficient of 1-2 shell & tube heat exchanger; Study and operation of a long tube evaporator.

CH 372 HEAT TRANSFER DESIGN LABORATORY 2 credits [0-0-3]

Design of heat exchangers; Shell and Tube; Plate type; Fin tube; Optimization of shell & tube heat exchanger using ASPEN PLUS; Optimization of double pipe heat exchanger using ASPEN PLUS; Design and optimization of condenser using ASPEN PLUS; Design of multiple effect evaporator system; Design of 1-2 shell & tube condenser; Design of jacketed vessel for unsteady state heating state heating of water; Design of stirred tank for unsteady state heating and cooling of water; Design of insulation; Study the effect of heat transfer augmentation on the heat transfer surface

CH 373 MASS TRANSFER FUNDAMENTAL LABORATORY 2 credits [0-0-3]

(a) Determination of diffusivity of acetone in air.; (b) Determination of mass transfer coefficient in an agitated vessel; (a) Determination of mass transfer coefficient for steady state surface evaporation of water at different temperature; (b) Determination of mass transfer coefficient in a wetted wall column; Determination of T-x-y diagram for a binary batch distillation; Verification of ***Rayleigh equation*** in a binary batch distillation process; Verification of steam distillation equations; Determination of ternary curve for the system acetic acid-water-carbontetrachloride; Determination of distribution coefficient of a solute in two immiscible liquids; Solid-Liquid extraction – Soxhlet's experiment; Liquid - liquid extraction in packed bed; Determination of adsorption kinetics and isotherm at solid-liquid interface; Determination of the rate of drying in a tray dryer; Estimation of efficiency of the fluidized bed dryer

CH 374 MASS TRANSFER DESIGN LABORATORY 2 credits [0-0-3]

Scope: The course includes process design and mechanical equipment design aspects of a few mass transfer equipments: Design of mass transfer equipments; (i) Continuous contractors; (ii) Stage contractors for various mass transfer operations viz absorption, leaching and Liquid-Liquid extraction; Design of equipments for combined heat and mass transfer operations viz. distillation, drying and humidification; Acquaintance with software in the design of various mass transfer equipments.

CH 375 BIOTECHNOLOGY LABORATORY 2 credits [0-0-3]

Different sterilization and inoculation techniques; Preparation of various types of media; Effect of pH, Substrate conc. on cell growth; Effect of temperature on cell growth; Determination of volumetric mass transfer co efficient (Kla); Determination of mixing time; Determination of size and density of the microbial cells; Determination of thermal death rate constant; Preparation of immobilized whole cell system; Substrate degradation, cell growth and product formation kinetics using free cells and whole cell immobilization; Treatment of sample waste water in a bioreactor; Production of Acetic acid using fermentor.

CH 376 PROCESS INSTRUMENTATION LABORATORY 2 credits [0-0-3]

(a) To study the operation of Flow well magnetic level switch to keep constant level in a tank; (b) Operation & working of ROTOLARM; (a) Study the principle, Callibration & measurement of P^{+1} of unknown sample using digital p^{H} meter; (b) Circular chart recorder; Study the operation of a turbidity meter & to find out the turbidity of a unknown chalk powder from calibration plot; Study the operation of conductivity meter, measuring specific conductance of solutions & determining the compositions of unknown solution from calibrated plot; (a) Study the operation of potentiometric recorder; (b) Study the operation of a temperature recorder, with strip chart; To study the static & dynamic characteristics of bimetallic, vapor pressure, thermometer, optical pyrometer & radiation pyrometer; Study of the characteristics of different thermocouples & RTD sensors; Determination of transient response of a vapor pressure & bimetallic thermometer. (With & without cover); (a) Determination of Dissolved oxygen using DO meter; (b) Determination of gas-fraction in gas-liquid mixture using conducting probe; Concentration analysis of hydrogen using gas-liquid chromatograph; Concentration analysis using U-V-visible spectrophotometer & to study its principle of action; Particle-size analysis using Malvern-Particle size analyzer & to study its principle of operation; (a) Composition analysis using digital refractometer & to study the principle of operation; (b) Determination of moisture content using IR-moisture balance; (a) Determination of viscosity of slurry using Brook-field viscometer & to study its principle of operation; (b) Measurement of Humidity using hair hygrometer & to study its principle; Pressure measurement using different pressure gauges, U-tube manometer, pressure transducer and study their characteristics.

CH 377	FLUID DYNAMICS APPLICATION LABORATORY	2 credits [0-0-3]

To determine the pressure drop in a packed bed by Leva's and Ergun's equation and verify experimentally; To determine the minimum fluidization velocity in a fluidized bed and verify experimentally; To determine the minimum fluidization velocity and pressure drop in a tapered fluidized bed; Determination of discharge coefficient with Reynold's Number in case of an orifice meter and a venturi meter; Determination of the minimum fluidization velocity and pressure drop in a square bed; Study of D'e laval Centrifuge and to find out its efficiency using it as a Clarifier and Purifier; Study and verification of the flow pattern in a Bernoulli's apparatus; Determination of the mixing and segregation index of the given sample of bed materials in a fluidized bed; Determination of the fluidization index of the given sample of bed materials in a fluidized bed; Acquaintance of Fluent Soft Ware (Part-I); Acquaintance of Gambit Soft Ware; Acquaintance of Fluent Soft Ware for the cylindrical tube.

CH 414	NANOTECHNOLOGY IN CATALYSIS	3 credits [3-0-0]

Introduction to nanotechnology, definition, history. What makes the nanoscale so different from the other lengthscales by considering the underpinning science (i.e.nanoscience) and some key examples of nanotechnology. Methods of synthesis of nanomaterials fabrication-"Top-down" vs. "bottom-up" approaches. Equipment and processes needed to fabricate nanodevices and structures. Fundamental understanding of catalysis at nano-scale. Wet chemical synthesis, preparation and properties of iron, platinum, gold, cadmium, silver, copper and nickel nano-particles. Synthesis and properties of composite nano-particles and coated nano-particles. Characterization of nano particles by Scanning probe microscopes (Atomic Force Microscopy, Scanning Tunneling Microscopy), Transmission Electron Microscopy, Scanning Electron Microscopy.

Essential Reading:

1. S. K. Kulkarni, ***Nanotechnology: Principles and Practices***, Capital Publishing Co. 2007.

Suggested Reading:

1. Tang, Zikang and Sheng, Ping, Taylor and Francis, ***Nano science and technology: novel structures and phenomena***, 2003.
2. B. Rogers, S. Pennathur, J. Adams, Taylor and Francis, ***Nanotechnology: Understanding small systems***, 2008.

CH 415	FLUIDIZATION ENGINEERING	4 credits [3-1-0]

Introduction to fluidization, Types of fluidization; Gross behavior of fluidized beds: Minimum fluidization velocity, pressure drops in fluidized beds, Bed voidage, TDH, Viscosity and fluidity of beds, Bubble behavior, Bed expansion, Distributor design, Simple mathematical treatment; Solid transport: Flow and fluidized solids, Solids transfer, Terminal velocity, Particle entrainment and elutriation, Simple calculations; Heat and mass transfer in fluidized beds : Heat transfer mechanism, Principles of gas-solid and bed surface transfer, Heat transfer to liquid fluidized systems, Generalised correlation for fluidized bed mass transfer and its limitations; Semifluidization: Principles, production of various bed parameters, Industrial applications; Design of fluidized bed reactors: Concept of RTD, Basic design principles for fluidized bed reactors.

Essential Reading:

1. D. Kunii and O. Levenspiel, ***Fluidization Engineering***.

Suggested Reading:

1. M. Leva, ***Fluidization***.
2. J S M Botterill, ***Fluid bed heat transfer***.
3. ***Current literature***.

Pre-requisite: Knowledge in under graduate "Fluid Dynamics"

CH 417	MODERN SEPARATION PROCESS IN CHEMICAL ENGINEERING	3 credits [3-0-0]

An overview: Separation techniques, separation from liquids, separation from gasses and vapors, separation from solids and separation methods in bioprocessing: aqueous two-phase separation, Reverse micelle extraction; Membrane separations: Definition of a membrane and membrane process such as microfiltration, reverse osmosis, ultrafiltration, dialysis, electrodialysis, gas permeation, pervaoration Characterization of membrane such as colloidal morphology, permeability and permeselectivity. Membrane modules such as plate and frame device, spiral wound, tubular and hollow-fiber; Membrane technology in gas separation, biotechnology and in food and biochemical industry; Ion Exchange: Ion exchange mechanism, ion exchange media, equilibrium, equipment and design procedure and industrial applications; Adsorption as a separation process: Thermodynamics of adsorption: basic relationship, Representation, correlation and prediction of single component adsorption equilibrium data and extension to multi-component adsorption equilibrium calculation: Isotherm expression of gas adsorption; Adsorption with chemical reaction and adsorption with biological growth; Chromatography separation: Fundamentals of HPLC, Chromatographic column, Development of gradient-elution separations. Basic principles of capillary electro chromatography, mobile phase composition, Stationery phases used in CEC; Solid separation processes: Physical properties of solids, classification of powders, particle size distributions, particle density, bulk density and porosity, forces of adhesion. Separation of particulates and powders. Wet separation process: Protein recovery, Soya processing and other applications.

Essential Reading:

1. J. D. Seader, and E. J. Henley, ***Separation process principles***, John Wiley & Sons Inc, 1998.

Suggested Reading:

1. Ruthern, M. Douglas, ***Encyclopedia of separation technology***, Wiley-Interscience, 1st edition, 1997.
2. J. S. Waston, ***Separation methods for waste and environment***, Marcel Dekker, 2000.
3. N. D. Richard, and T. Patricia, ***Principle of Chemical separations with environmental applications***, 2004.
4. S. Ahija, ***Handbook of Bioseparations***, ***Academic Press***, 2000.
5. Hunter, J. Robert, ***Foundation of Colloid Science***, Vol II 2000.

CH 418 RECENT SEPARATION TECHNOLOGY 3 credits [3-0-0]

Adsorption: Concepts and definitions; adsorbents and their preparation and properties; adsorption isotherms and their importance; adsorption types; equipments; adsorption in fixed bed; methods regenerations of adsorbents and basic mathematical modeling. **Chromatography separation**: Basic principal; different types of chromatographic separation techniques and their application. **Membrane separation technique:** membrane classification, chemistry, structure and characteristics and preparation; various membrane separations technology such as microfiltration, ultrafiltration, reverse osmosis, dialysis, electrodialysis, gas permeation, pervaoration, liquid membrane and their applications in chemical, biotechnology, food, and biochemical industry. **Reactive Distillation:** Concept, modeling and design aspects and applications. **Supercritical Fluid Extraction:** Concept, modeling and design aspects and applications. **Biofiltration:** Concept, modeling and design aspects and applications.

Essential Reading:

1. B. K. Dutta, ***Principles of Mass Transfer and Separation Processes***, Prentice Hall of India Private Limited, 2007.
2. R. W. Baker, ***Membrane Technology and Applications***, John Wiley & Sons Ltd, 2004.

Suggested Reading:

1. M. C. Porter, ***Handbook of Industrial Membrane Technology***, Crest Publishing House, 2005.
2. M. Mukhopadhyay, ***Natural extracts using supercritical carbon dioxide***, CRC Press, LLC, Boca Raton, Florida, USA, 2000.
3. R. G. Harrison, P. W. Todd, R. Scott, ***Bioseparations Science and Engineering***, Oxford University Press.
4. J. E. Bailey and D. V. Ollis, ***Biochemical Engineering Fundamentals***, Mc-Graw Hill, 1986
5. J. G. S. Marcano and T. T. Tsotsis, ***Catalytic membranes and membrane reactor***, John Wiley, 2002.

CH 419 COMPUTATIONAL FLUID DYNAMICS 4 credits [3-1-0]

Introduction to CFD; Basic Concepts and Equations of Fluid Dynamics; Basic Concepts, Continuum model of a fluid, Kinematics, Steady and unsteady flow, Description of fluid motion by Lagrangian method, Eulerian method. Acceleration of a fluid particle, Forces acting on a fluid particle, Laws governing fluid motion, derivation of governing equation, continuity equation, Navier Stokes equation and its derivation, Energy equation, Chemical reacting flows. Equations of motion in conservation and vector forms. Non-dimensional form of equations, equations in orthogonal and curvilinear coordinates; Simplified forms of equations: Euler's equation, Velocity potential equation; Reynold's equation for turbulent flow: Averaging procedure, Mass weighted averaging, Reynold's form of continuity equation, Reynold's form of momentum equation, Reynold's form of energy equation, Boundary layer equations; Momentum integral equations, Vorticity transport equations, Conservative and body force fields; Turbulence Modeling Large Eddy Simulation; Governing equations, Models of turbulence, Large eddy simulation and detached eddy simulation; Mathematical behaviour of Governing equations in CFD; Mathematical preliminaries; Finite difference method, Finite volume method; Simulation of Incompressible Flow using Lattice-Boltzmann Method; Introduction; Lattice Gas method; Lattice-Boltzmann Method; CFD for Process Equipment Application; Modeling of some physical phenomena encountered in CPI; Examples of application of CFD to CPI, Review of status of CFD for CPI applications.

Essential Reading:

1. C. A. J. Fletcher and C. A. Fletcher, ***Computational Techniques for Fluid Dynamics – I,*** Springler, ***2nd edition, 1996***.

Suggested Reading:

1. R. Lohner, ***Applied computational fluid dynamic Technique***, John Wiley & Sons, 2001
2. D. A. Handerson, ***Computational Fluid Mechanics and Heat Transfer***.
3. T. K. Bose, ***Numerical Fluid Dynamics***.

Pre-requisite: Knowledge in under graduate "Fluid dynamics"

Pre-requisite: Knowledge in under graduate "Basic chemistry"

CH 421	REACTION KINETICS AND CATALYSIS	4 credits [3-1-0]

Homogeneous Reactions: Classifications of reactions, definition of reaction rate, variables affecting the rate, order of reaction and its determination, theoretical study of reaction rates-The Arrhenious relationship, Collision theory and activated complex theory, molecularity; interpretation of kinetic data for batch and flow systems, integral and differential methods of analysis; design of batch, semi-batch and flow (Tubular & Tank) reactors for single ideal reactions, reactions in series and parallel and mixed reactions under isothermal operations; design of adiabatic and non-isothermal reactors; introduction to enzyme kinetics. Heterogeneous reactions: examples; classification of catalysts, general procedure for manufacture of catalysts, catalytic promoters and poisons, reactions catalyzed by solid catalysts; engineering properties of catalysts and their determination, general mechanism of catalytic reactions, adsorption isotherms; transport processes in reactions catalyzed by solids; design of heterogeneous catalytic reactors.

Essential Reading:

1. O. Levenspiel, ***Chemical Reaction Engineering***, John Wiley & Sons, 1999.
2. H. S. Fogler, ***Elements of Chemical Reaction Engineering***, Prentice Hall of India Private Limited, 1999

Suggested Reading:

1. G. F. Froment and K. B. Bischoff, ***Chemical Reactor Analysis and Design***, John Wiley, 2001.
2. J M Smith, ***Chemical Engineering Kinetics***, Mcgraw & Hills, 1981.

CH 422	SIMULATION, MODELLING AND OPTIMISATION OF CHEMICAL PROCESS	4 credits [3-1-0]

Simulation: Techniques of digital simulation – Information flow, from process to information flow diagram, From information flow diagram to numerical form, Recycles, Calculation of a recycle set, etc; Digital simulation of C. S. T. R. s in series, non-isothermal C. S. T. R, Binary distillation column, Batch reactor, Computer aided design; Modeling: Fundamentals of mathematical models and formulation – Continuity equation, Equation of motion, Transport equations, Energy equation, Equations of state, Equilibrium, Chemical kinetics and their applications; Lumped and distributed parameter models – Fluid systems, C. S. T. R. (single, series, isothermal, constant hold up, variable hold up, gas phase pressurized and non-isothermal), Single component vaporizer, Multi-component flash drum, Batch reactor, Reactor with mass transfer, Ideal binary distillation column, Batch distillation, Heat exchanger, etc; Optimization: Single variable optimization (analytical, dichotomous search, fibonacci, golden section, regula falsi), Multivariable optimization (analytical, geometric programming, linear programming), Convergence methods (Newton's methods, direct substitution, Wegstein's method).

Essential Reading:

1. W. L. Luyben, ***Process Modelling, Simulation and Control for Chemical Engineers,*** McGraw Hill, 1990.

Suggested Readings:

1. B. V. Babu, ***Process Plant Simulation***, Oxford University Press, 2004.
2. S. S. Rao, ***Engineering Optimization: Theory and practice***, New Age Publishers, 1999.
3. A. Hussain and K. Gangaiah, ***Optimisation Techniques for Chemical Engineers***, Macmillan, 2001.
4. B. W. Bequette, ***Process Control: Modeling, Design and Simulation.*** Prentice-Hall India, 2006.

CH 425	ENVIRONMENTAL ENGINEERING	3 credits [3-0-0]

Importance of environment for mankind, Damages due to environmental pollution; Air pollution: Introduction, Composition of air and nature of air pollution, Classification of pollutants and their nature, Sources of air pollutants and their effects; Meteorological factors influencing air pollution, Methods of estimation of various types of pollutants in air, Air pollution problem in few typical chemical industries, Approaches to air pollution control, Control equipment for particulate emissions and gaseous pollutants, Pollution from mobile sources, Air quality criteria and standards; Water pollution: Waste water treatment – evaluation, classification of wastes, Control of water pollution, Characterisation of waste waters; Methods and equipment – preliminary treatment and disposal, Treatment of industrial wastes from a few typical chemical industries, Standards.

Essential Reading:

1. M. L. Davis and D. A. Cornwell, ***Introduction to Environmental Engineering***, Tata McGraw & Hills, 2007

Suggested Reading:

1. L. K. Wang, ***Air pollution control Engineering***, ***Humana Press Inc***., U. S.; 2Rev Ed edition, 2004
2. R. Weiner and R. Matthews, ***Environmental Engineering***, Butterworth-Heinemann, 2003.

CH 426	COAL PROCESSING TECHNOLOGY	3 credits [3-0-0]

Role of coal in the overall energy situation; Recent advances in coal preparation methods including fine coal treatment; Simulation and modeling of coal beneficiation circuits; Thermodynamics and kinetics of coal gasification reactions; Fluidized bed coal gasification processes; Combined cycle power generation; Coal liquefaction: Various methods, kinetics of solvent extraction, catalytic hydrogenation and other liquefaction processes; Concept of coal refinery and coalplex; Environmental impact analysis of coal utilization methods such as carbonization, gasification, etc.

Essential Reading:

1. H. L. Lowary, ***Chemistry of Coal Utilization, Vol. I & Vol. II***.

Suggested Reading:

1. Mangold, ***Liquefaction and Gasefication of Coal.***
2. Wilson and Wales, ***Coal, Coke and Coal Chemicals.***

CH 427	COLLOID AND INTERFACIAL ENGINEERING	3 credits [3-0-0]

General introduction of colloids, interfaces, surfactants, and micellization.; Intermolecular forces, Van der Waals forces (Keesom, Debye, and London interactions), Colloidal systems and colloidal stability (van der Waals attraction and potential energy curves), Brownian motion and Brownian flocculation. Surface and interfacial tension and surface free energy, Surface tension for curved interfaces, Surface excess and Gibbs equation. Theory of surface tension and contact angle, and wetting. Thermodynamics of interfaces, thermodynamics of micelle and mixed micellar formation. Electrical phenomena at interfaces (Electrokinetic phenomena, Electrical double layer). Emulsion and micro-emulsion.; Application: General applications, Enhanced petroleum recovery, super hydrophobic and self cleaning surfaces, novel fabrication of nanostructured particles. Measurement techniques of surface tension, Contact angle, Zetapotential, Particle size.

Essential Reading:

1. P. C. Hiemenz, and R. Rajagopalan, ***Principle of colloid and surface chemistry,*** 3rd edition, Mercel Dekher, N. Y. 1997.
2. D. J. Shaw, ***Colloid & Surface Chemistry, Butterworth Heinemann***, Oxford, 1992.

Suggested Reading:

1. M. J. Rosen, ***Surfactants and Interfacial Phenomena***, Wiley-Interscience Publication, New York, 2004.
2. Adamson, A. W. Gast, ***A. P. Physical Chemistry of Surfaces,*** Wiley-Interscience, New York, 1997.
3. J. Israelachvili, ***Intermolecular and Surface Forces***, Academic Press, New York, 1992.

Pre-requisite: Knowledge in under graduate "Basic chemistry"

CH 428	DISASTER MANAGEMENT IN CHEMICAL INDUSTRIES	3 credits [3-0-0]

General aspects of industrial disaster: Due to fire, explosion, toxicity and radiation; Chemical hazards: Classification of chemical hazards, Chemical as cause of occupational diseases – dust, fumes, gases and vapours; Hazard analysis and health management; Engineering control of chemical plant hazards – Plant layout, ventilation and lighting, Pressure vessels, Storage, Handling, Transportation, Electrical systems, Instrumentation; Emergency planning, Personal protective devices, Maintenance procedure; Emergency safety and laboratory safety; Legal aspects of safety, Management information system and its application in monitoring disaster, safety and health; Hazop Analysis.

Essential Reading:

1. H. H. Tawcatt & W S Wood, ***Safety and Accident Prevention in Chemical Operations***.

Suggested Reading:

1. R. V. Betrabet and T. P. S. Rajan in CHEMTECH-I, ***Safety in Chemical Industry***, Chemical Engineering Development Centre, Madras, 1975.
2. Wells, ***Safety in Process Plant Design***.
3. Less, P. Frank, ***Loss Prevention in Process Industries***.
4. J. Lolb & S. Roy Sterm, ***Product Safety and Liability.***

CH 432	OPTIMIZATION TECHNIQUES IN PROCESS DESIGN	3 credits [3-0-0]

Optimal problem formulation, Single variable optimization algorithms including interval halving; golden section search; Newton-Raphson method; bisection method; root finding using optimization techniques, Multi variable optimization algorithms including simplex search method; Cauchy's steepest descent method; Levenberg Marquardt's method, constrained optimization algorithms including Khun-Tucker conditions, transformation methods; direct search methods; liberalized search techniques; feasible direction method, Specialized algorithms including Integer programming; geometric programming. Nontraditional optimization technique like simulated annealing. Application of the aforesaid techniques in Chemical Engineering designs, like optimum insulation thickness, shell and tube heat exchanger design.; Scope & Objective: Optimization has become a part of computer aided design activities where the goal is not only to achieve a feasible design but also a design objective. The course provides basic knowledge of deterministic algorithms as well as algorithms which are stochastic in nature with probabilistic transition rules, new methods in computational intelligence or 'soft computing' inspired by evolutionary processes in nature, such as genetic algorithms. The course consists of lectures and a project component, which includes both model building and programming. This course also provides an opportunity to get conversant with optimization toolbox of MATLAB by the Mathworks, Inc.

Essential Readings:

1. T. F. Edgar, D. M. Himmelblau, ***Optimization of Chemical Processes***, Mcgraw-Hill College Division, 1987.

Suggested Readings:

1. B. V. Babu, ***Process Plant Simulation***, OUP, India, 2004.
2. S. S. Rao, ***Engineering Optimization Theory & Practice***, John Wiley & Sons Inc, 1996.

CH 434	PROJECT ENGINEERING	3 credits [3-0-0]

Introduction to the subject; **Development and implementation of the project in the following steps:** Initial conception; Preliminary design ideas and rough evaluation of market and economics; Procuring data for final design; Final economic evaluation and decision set up the project; Detailed design; Procurement; Construction work; Start up and trail runs; Commercial production; Safety consideration; **Process Design;** Selection of process cycle; Chemical process considerations; Qualitative block type process flow sheet; Material balance and energy balance; Selection of process equipment and its computer aided design using Fortran language to various engineering problems; Plant layout: Planning layout and methods of layout planning; **Economic evaluation of the project;** Capital Cost; Plant cost estimating; **Total product cost:** Manufacturing cost; Raw material cost; Miscellaneous cost (labour cost, repair cost and maintenance cost); Depreciation; Economic Analysis: Net earning profitability analysis; Introduction to optimization.

Essential Reading:

1. Peters – Timmerham (International Editions), ***Plant Design and Economics for Chemical Engineers***, McGraw Hill Book Co.

Suggested Reading:

1. F. C. Viberandt and C. E. Dryden (International Students Editions), ***Chemical Engineering Plant Design***, McGraw Hill Book Co.
2. B. S. Golfried, ***Theory and Problems of Programming with Fortran: Schaum's Outline Series,*** Tata McGraw Hill.

CH 439	NON-TRADITIONAL AND TRADITIONAL OPTIMIZATION TECHNIQUES	3 credits [3-0-0]

Optimal problem formulation, Single variable optimization algorithms, Multi variable optimization algorithms including simplex search method; Cauchy's steepest descent method; Levenberg Marquardt's method, constrained optimization algorithms including Khun-Tucker conditions, transformation methods; direct search methods; liberalized search techniques; feasible direction method, Specialized algorithms including Integer programming; geometric programming. Nontraditional optimization techniques including simulated annealing, genetic algorithms (GA), introduction to multi objective optimization problems. Application of all the aforesaid techniques with the help of the frequently used benchmark functions for engineering design.; Scope & Objective: ; Optimization has become a part of computer aided design activities where the goal is not only to achieve a feasible design but also a design objective. The course provides basic knowledge of deterministic algorithms as well as algorithms which are stochastic in nature with probabilistic transition rules, new methods in computational intelligence or 'soft computing' inspired by evolutionary processes in nature, such as genetic algorithms. The course consists of lectures and a project component, which includes both model building and programming. This course also provides an opportunity to get conversant with optimization toolbox of MATLAB by the Mathworks, Inc.

Essential Reading:

1. S. S. Rao, ***Engineering Optimization Theory & Practice***, John Wiley & Sons Inc, 1996.

Suggested Reading:

1. K. Deb, ***Multi-Objective Optimization Using Evolutionary Algorithms***, John Wiley Sons, 2001.
2. B. V. Babu, ***Process Plant Simulation***, OUP, India, 2004.
3. T. F. Edgar, D. M. Himmelblau, ***Optimization of Chemical Processes***, Mcgraw-Hill College Division, 1987.

CH 470	PROCESS SIMULATION LABORATORY	2 credits [0-0-3]

Steady state simulation of Heat Exchanger using ASPEN PLUS/ HYSYS; Steady state simulation of a CSTR using ASPEN PLUS/ HYSYS; Steady state simulation of Flash vessel using ASPEN PLUS/ HYSYS; Steady state simulation of Distillation Column using ASPEN PLUS/ HYSYS; Steady state simulation of an Absorption column using ASPEN PLUS/ HYSYS; Dynamic simulation of Heat Exchanger using ASPEN PLUS/ HYSYS; Dynamic simulation of a CSTR using ASPEN PLUS/ HYSYS; Dynamic simulation of Flash vessel using ASPEN PLUS/ HYSYS; Dynamic simulation of Distillation Column using ASPEN PLUS/ HYSYS; Dynamic simulation of an Absorption column using ASPEN PLUS/ HYSYS

CH 471	CHEMICAL REACTION ENGINEERING LABORATORY	2 credits [0-0-3]

Study and operation of a packed bed reactor; Study and operation of a batch reactor; Study and operation of a CSTR; Study and operation of a plug flow reactor; Study and operation of a cascade CSTR; Study and operation of an adiabatic batch reactor; Study and operation Trickle bed reactor; Study and operation Condensation polymerization reactor; Study and operation Emulsion polymerization reactor; RTD study in a CSTR; RTD study in a plug flow reactor; Study and operation of a coiled tubular reactor

CH 473	COMPUTER AIDED DESIGN LABORATORY - II	2 credits [0-0-3]

Finding out matrix addition, multiplication, inversion, rank, Eigen values using MATLAB simulator.; Plotting set of data using MATLAB; Parameter estimation using least-square technique using MATLAB; Writing 'm' files in MATLAB platform to solve coupled linear algebraic equations using Gauss elimination method; Writing 'm' files in MATLAB platform to solve non-linear algebraic equations using Newton Raphson Technique; Writing 'm' files in MATLAB platform to control level in a tank using P/PI/PID controller; Finding out response of a first and second order system (transfer function) using 'simulink'; Simulation of a stirred tank reactor (both open loop and closed loop) using 'simulink'; Simulation of steady Flow of air through a cylindrical tube using GAMBIT and FLUENT; Simulation of steady state fluid flow and heat transfer processes using GAMBIT and FLUENT when liquid water flows through a cylindrical tube; Simulation of steady Flow of air through a 'T' joint using GAMBIT and FLUENT.

CH 475	PROCESS DYNAMICS & CONTROL LABORATORY	2 credits [0-0-3]

Transient response to single tank system with storage & Flow to (a) step change (b) impulse change in put; Transient response of non interacting system in series; Transient response of interacting system in series; Study the operation of ON-OFF electronic temperature controller & determination of its performance to control the temperature of a system having capacity to store thermal energy; Study the principle of operation & working of pneumatic servo system with various input functions; Transient response of a CSTR System to step change; Controlling a batch reactor using digital PID controller; Study the dynamics of parallel & counter flow shell & tube heat exchanger; Controlling of Parallel Flow & counter flow STHE using digital PI controller to have desired output; Dynamics characteristics of mercury & water manometers; Study of control value characteristics; Study the performance of cascade control system & to maintain desired level in a tank, with flow; Study the dynamics of bubble cap distillation column; Control of a bubble cap distillation column using digital PID controller; Study of effect of PID controller on pressure process trainer.

DEPARTMENT OF CERAMIC ENGINEERING

DETAILED SYLLABI OF COURSES

CR 211	Unit Operations in Ceramic Processing	3-1-0	4
CR 212	Ceramic Processing	3-1-0	4
CR 219	Introduction to Ceramics	3-0-0	3
CR 223	Materials Thermodynamics	3-0-0	3
CR 226	Pollution & Waste Management in Ceramic Industry	3-0-0	3
CR 230	Science of Ceramic Materials	3-1-0	4
CR 231	Properties of Ceramic Raw Materials	3-1-0	4
CR 244	Introduction to Engineering Materials	3-0-0	3
CR 248	Fuels, Furnace and Stoichiometry	3-0-0	3
CR 249	Materials Science & Engineering	3-0-0	3
CR 271	Raw Materials Analysis Laboratory	0-0-3	2
CR 272	Drawing of Refractory Lining and Joints	0-0-3	2
CR 273	Ceramic Workshop	0-0-3	2
CR 274	Ceramic Fabrication Laboratory	0-0-3	2
CR 310	Refractories or Refractory	3-0-0	3
CR 320	Science of Sintering	3-1-0	4
CR 322	Glass Technology	3-0-0	3
CR 325	Computational Materials Science	3-0-0	3
CR 327	Interface Science & Sol-Gel Processing	3-1-0	4
CR 330	Fuel Cell & Batteries	3-1-0	4
CR 331	Whiteware Technology	3-0-0	3
CR 333	Heat Transfer and Fluid Flow	3-1-0	4
CR 335	Instrumental Characterization	3-1-0	4
CR 336	Cement Technology	3-1-0	4
CR 339	Ceramics in Electronic Applications	3-0-0	3
CR 341	Physical Ceramics	3-1-0	4
CR 344	Microstructural Design in Ceramics	3-0-0	3
CR 346	Nanoceramics	3-1-0	4
CR 348	Introduction to Engineering Ceramics	3-0-0	3
CR 370	RefractoriesTechnology Laboratory	0-0-3	2
CR 371	High Temperature Processing Laboratory	0-0-3	2
CR 372	Glass Technology Laboratory	0-0-3	2
CR 373	Whiteware Technology Laboratory	0-0-3	2
CR 374	Ceramic Product Development Laboratory	0-0-3	2
CR 375	Ceramic Characterization Laboratory	0-0-3	2
CR 376	Cement Technology Laboratory	0-0-3	2
CR 377	Ceramic Equipment Design Laboratory	0-0-3	2
CR 391	Special Topic in Ceramic Engineering – I		3/4
CR 392	Special Topic in Ceramic Engineering – II		3/4
CR 393	Special Laboratory in Ceramic Engg – I	0-0-3	2

CR 394	Special Laboratory in Ceramic Engg – II	0-0-3	2
CR 395	Engineering Product Development Project – I	0-0-6	4
CR 396	Engineering Product Development Project – II	0-0-6	4
CR 411	Advanced Ceramics	3-1-0	4
CR 415	Bio-ceramics	3-0-0	3
CR 416	Application of Refractories	3-1-0	4
CR 417	Unshaped Refractories	3-1-0	4
CR 418	Nanomaterials	3-0-0	3
CR 419	Biomaterials for Artificial Implants	3-0-0	3
CR 420	Glass Ceramic Technology	3-1-0	4
CR 421	Glasses for Advanced Technical Applications	3-1-0	4
CR 422	Ceramic Equipment Design	3-0-0	3
CR 424	Composite Materials	3-0-0	3
CR 426	Tribology of Materials	3-0-0	3
CR 433	Sensor Technology	3-0-0	3
CR 435	Functional Materials & Devices	3-0-0	3
CR 441	Electrical and Magnetic Ceramics	3-1-0	4
CR 445	Application of Phase Diagrams	3-1-0	4
CR 446	Thin Film and Coatings	3-0-0	3
CR 471	Advanced Ceramics Laboratory	0-0-3	2

For B. Tech. Courses (3 or 4 level) please refer to the B. Tech. Curriculum and Syllabi, for M. Tech Courses (6 level) please refer to M. Tech Curriculum and Syllabi.

CR 211 UNIT OPERATIONS IN PROCESSING 4 credits [3-1-0]

Communition: different type of communition equipment and theory of size reduction. Efficiency and particle size, size reduction and size distribution. Bulk solid transport and mixing. Mixing mechanism and mixedness. Mixing equipment types and operation. Consistency, particle mechanics and deformation behaviour of powders, slurries and paste. Particle classification-screening technique, cyclone separators, centrifuge. Filtration and washing process. Plastic forming, extrusion mechanics, control of types and operations. Basic concept of drying, costs involved in drying of ceramic, drying mechanisms in particulate systems, characterization of drier operations, drier controls, drying defects and drying shrinkage, advanced drying technologies.

Essential Reading:

1. W. L. McCabe, J. C. Smith and P. Harriot, ***Unit Operations of Chemical Engineering***, 7th Ed. McGraw-Hill Professional 2005.
2. J. S. Reed, ***Introduction to the Principles of Ceramic Processing***, 2nd Ed., John Wiley & Sons. 1995.
3. D. A. Brosan and G. C. Robinson, ***Introduction to Drying of Ceramics: with laboratory exercises***, NetLibrary, Incorporated, 2003.

Supplementary Reading:

1. A. M. Gaudin, ***Principles of Mineral Dressing***, Tata McGraw-Hill Publishing Company Limited, New Delhi 2003.
2. M. N. Rahaman, ***Ceramic Processing***, CRC Press, 2003

CR 212 CERAMIC PROCESSING 4 credits [3-1-0]

Significance of different ceramic processing operations. Powder synthesis, Colloidal and sol-gel processing. Powder characterization: Particle size, size distribution, Shape, Surface Area, Porosity, Chemical and Phase composition. Preparation of bodies: Blending of different weight fractions and size ratios, use of binders, types of binders; clay, molecular binder, film forming binders. Plasticizers, Foaming and antifoaming agents, granulation and spray drying. Dry pressing, Semi-dry pressing, Slip casting, Extrusion, Nontraditional shape forming: Gel casting, Tape casting, Freeze Casting, Injection moulding, Electro-phoretic deposition, Hot -pressing, Iso-static pressing; porosity, pore structure, drying defects; High temperature processing. .

Essential Reading:

1. J. S. Reed, ***Introduction to the Principles of Ceramic Processing***, 2nd Ed., John Wiley & Sons. 1995.
2. M. N. Rahaman, ***Ceramic Processing and Sintering***, 2nd Ed, CRC Press, 2003.

Supplementary Reading:

1. D. W. Richerson, ***Modern Ceramic Engineering: Properties, Processing, and Use in Design,*** 3rd ed, CRC Press, 2005
2. D. A. Brosan and G. C. Robinson, ***Introduction to Drying of Ceramics: with laboratory exercises***, Net Library, Incorporated, 2003.
3. H. Mehrer, ***Diffusion in Solids: Fundamentals, Methods, Materials, Diffusion-Controlled Processes***, Springer, 2007.

CR 219	INTRODUCTION TO CERAMICS	3 credits [3-0-0]

Introduction, definition and scope of ceramics. Historical perspective, classification, Ceramics and Civilization; Traditional ceramics: An overview, history, compositions, manufacturing and application of refractories, whitewares and heavyclay wares, glass, cement, ceramic coatings The development of modern ceramic technology, processing of ceramic powders, shape forming operations: pressing, slip casting, isostatic pressing, injection moulding, sheet forming, MLC technology. Firing of ceramics: kiln design and conveyor technology, sintering and densification, hot pressing and hot isostatic pressing. Sol –gel processing and monolithic ceramics. Basic glass processing, container glass, fibre glass, speciality glass products, glass- ceramics, glass microspheres, laminated glass, photochrome and photo sensitive glass Modern / high tech ceramics, high tech functions and functional ceramics, structural ceramics, electrical and electronic ceramics, chemical and nuclear ceramics, bio-ceramics, ceramic membranes, artificial gems and ceramics, aerospace and other strategic applications of ceramics, advanced ceramic processing techniques. Energy and pollution controls.

Essential Reading:

1. W. D. Kingery, H. K. Bowen and D. R. Uhlmann, ***Introduction to Ceramics***, 2nd Ed. John Wiley & Sons, Singapore, 1991.
2. D. W. Richardson, B. J. Dunbar, ***The Magic of Ceramics***, American Ceramic Society, 2000.

Supplementary Reading:

1. J. B. Wachtman Jr., ***Ceramic Innovations in the 20th Century***, American Ceramic Society, 1999.

CR 223	MATERIALS THERMODYNAMICS	3 credits [3-0-0]

Introduction, concept of states, systems equilibrium. Equation of states, extensive and intensive properties homogeneous and heterogeneous systems. Internal energy, heat capacity, enthalpy, isothermal, and adiabatic processes; The Second law of thermodynamics, entropy, enthalpy concepts, degree of reversibility and irreversibility, criteria of equilibrium, auxiliary functions, combined statements, Maxwell's relations, transformation formula, Gibbs-Helmoltz equation; Concept of Third law, temperature dependence of entropy, statistical interpretation of entropy, Debye and Einstein concept of heat capacity, relation between C_p and C_v; Fugacity, activity, equilibrium constant, homogeneous and heterogeneous equilibria. Ellingham-Richardson diagrams and applications; Solution thermodynamics, partial molal quantities, ideal and non-ideal solutions, Henry's law, Gibbs - Duhem equation, regular solution, quasi-chemical approach to solution; Statistical thermodynamics. Change of standard state. Phase equilibrium and phase rule.

Essential Reading:

1. D. R. Gaskell, ***Introduction to the Thermodynamics of Materials***, Taylor & Francis, 2003.
2. J. M. Smith, H. C. V. Ness, and M. M. Abbott, ***Introduction to Chemical Engineering Thermodynamics***, 7th Ed, McGraw-Hill Professional, 2005.

Supplementary Reading:

1. A. Ghosh, ***Textbook of Materials and Metallurgical Thermodynamics***, PHI Learning Pvt. Ltd, 2004

CR 226	Pollution & Waste Management in Ceramic Industry	3 credits [3-0-0]

Pollution and waste generation in ceramic and related industries. Kiln and stack emissions, pollution from service units like air compressor, laboratories, gas producers, storage facilities, waste water treatment plant etc; Environmental and health impacts of pollutants and solid wastes. Indian environmental laws and WHO's norms. Pollution reduction measures in ceramic industries: air, sound, solid waste, water. Nature and type of industrial waste useful for ceramic industries. Use of industrial wastes in ceramic industries Utilization of fly ash, rice husk, BF slag in the production of traditional, advanced ceramics. Utilization of red mud and recovery of metals from red mud. Application of zeolite in environment (catalytic effect, water purification). Clay as an absorbent of toxic pollutant; Recycling of industrial waste. Fluorine contamination in alumina Industry disposal and recovery of refractory materials. Ceramics for water and air purification. Glass & glass ceramics in nuclear waste management

Essential Reading:

1. P. V. Rao, ***A Text Book of Environmental Engineering***, Prentice Hall of India Private Limited, 2002.
2. C. C. Herman (Editor), S. Marra (Editor), D. R. Spearing (Editor), L. Vance (Editor) and J. D. Vienna (Editor), ***Environmental Issues and Waste Management Technologies XI***, ***Ceramic Transactions, Volume 176***. John Wiley & Sons, edition, 2005.

Supplementary Reading:

1. S. K. Sundaram, D. R. Spearing, and J. D. Vienna, ***Environmental Issues and Waste Management Technology in the Ceramic and Nuclear Industries VIII***, ***Ceramic Transactions, Volume 143,*** The American Ceramic Society, 2002.
2. S. M. Khopkar, ***Environmental Pollution: Monitoring and Control***, New Age International (P) Ltd, 2004.

CR 230	SCIENCE OF CERAMIC MATERIALS	4 credits [3-1-0]

Crystal lattice, crystal class and crystal system. Some Real Structures: Rock Salt, Zinc Blende, Antifluorite, Rutile, Perovskite, Spinels, Wurtzite etc. Crystal imperfections: types and notations, Solid solutions, defects and dislocations. Vitreous state, glasses and structural models; Condensed phase rule and single component system: Silica, Zirconia and Carbon etc. Two component systems and Lever rule. Free energy-composition diagrams, phase stability, solid solutions, Eutectic and Eutectoid, Peritectic reaction, congruently and incongruentlymelting compound. Some important binary ceramic systems SiO_2-Al_2O_3, MgO-Al_2O_3, CaO-SiO_2, CaO-ZrO_2, MgO-SiO_2, BaO-TiO_2, CaO-Al_2O_3, CaO-MgO; Ternary System: Representation of composition on triangle, proof of the basis, Temperature, Solid models, Iso-thermal Sections, Base projection method. Ternary systems with binary and ternary Eutectic, Peritectic, congruently and incongruently melting compounds. Some important ternary ceramic systems**:** CaO-SiO_2-Al_2O_3, MgO-SiO_2-Al_2O_3, CaO-MgO-SiO_2. Brief idea on the application of real system binary, ternary and quaternary phase diagrams in the processing and process control of different ceramic materials.

Essential Reading:

1. W. D. Kingery, H. K. Bowen and D. R. Uhlmann, ***Introduction to Ceramics***, 2nd Ed. John Wiley & Sons, Singapore, 1991.
2. L. V. Azaroff, ***Introduction to Solids***, Tata McGraw Hill Publishing Co. Ltd, 1977.
3. F. A. Hummel, ***Introduction to Phase Equilibrium in Ceramic Systems***, First Edition, CRC Press, 1984.

Supplementary Reading:

1. C. Kittel, ***Introduction to Solid State Physics***, 8th Ed. John Wiley & Sons Pvt. Ltd, 2004.
2. 2. G. Smith, R. S. Roth, T. Negas and L. P. Cook, ***Phase Diagrams for Ceramists***, American Ceramic Society, 1983

CR 231	PROPERTIES OF CERAMIC RAW MATERIALS	4 credits [3-1-0]

Classification of raw materials, beneficiation of raw materials, importance, use and limitations of natural raw materials: Bauxite, Limestone, Chromite, Magnesite, Dolomite, Fluorite, Graphite, Gypsum, Haematite, Kaolinite, Fireclay, Ball clay, Montmorillonite, Magnetite, Nepheline Syenite, Microcline, Feldspars (soda, potash, lime), Pyrophyllite, Quartz, Quartzite, Sillimanite, Kyanite, Andalusite, Talc, Wollastonite, Zircon, Beryl, Mica, Vermicullite, Silica sand etc; Brief idea on processing of synthetic raw materials: Bayer process, Calcined Alumina, Tabular Alumina, FusedAlumina, Sea-water Magnesia, ZirconandZirconia, Titania, Magnesio-AluminateSpinel, FumedSilicaetc. The application areas and limitations of synthetic raw materials; Effect of heat on different raw materials with reference to phase transformation, thermal expansion, melting, decomposition behaviour, compound formation, stabilization.

Essential Reading:

1. W. E. Worrall ***Clays and Ceramic Raw Materials***, 2nd edition, Springer, 1986.
2. W. L. McCabe, J. C. Smith and P. Harriot, ***Unit Operations of Chemical Engineering***, 7th Ed. McGraw-Hill Professional 2005.

Supplementary Reading:

1. D. Segal, ***Chemical Synthesis of Advanced Ceramic Materials***, CambridgeUniversity Press, 1991.

CR 244	INTRODUCTION TO ENGINEERING MATERIALS	3 credits [3-0-0]

Atomic Structure and Bonding. Crystal Structure, crystal class and crystal geometry: Polymorphism; crystal structure analysis, crystalline Imperfections: point defect and line defects. Diffusions in Solids and phase transformations, thermal and athermal transformations. Solid solutions. Solidification: Solidification of metals and single crystals; Brief idea of crystal growth techniques; Mechanical Properties of Metals: Stress and strain, hardness. Strengthening; Recovery and recrystallization; Strength, Fracture toughness, creep and fatigue. Engineering alloys: Fe-C phase diagram; Heat treatment of steel; Classification of steel; Polymeric Materials: Basic structure– simple and network molecules; Physical states and transitions; Plasticization; Crystallinity; Polymerization, Degradation and stabilization of polymers, Vulcanization of rubber. Application of polymers, conducting polymers; Composite Materials: Definition;

Types of composites, properties and applications; strength and toughness in composites, layered composites, particulate and fibre reinforced composites; Electrical, Magnetic and Optical Properties of Materials: Classification, Electrical and electronic conduction, polarization, dielectric properties, application. BCS theory and Superconducting Materials.

Essential Reading:

1. W. F. Smith, ***Foundations of Materials Science and Engineering***, McGraw-Hill Professional, 2003.
2. V. Raghavan, ***Materials Science and Engineering***, 4th Ed, Prentice-Hall of India Pvt. Ltd, New Delhi, 2004.

Supplementary Reading:

1. J. F. Shackelford and M. Meier, ***Introduction to Materials Science for Engineers***, Prentice Hall PTR, 2005.
2. F. Rodrigues, C. Cohen, C. K. Ober and L. A. Archer, ***Principles of Polymer System,*** 5th Ed. Taylor & Francis, 2003.

CR 248	FUELS, FURNACES AND STOICHIOMETRY	3 credits [3-0-0]

Classification of natural fuels, Brief discussion on alternate and renewable energy sources, winning and washing of coal, classification of coal, proximate and ultimate analysis of coal. Storage of coal and spontaneous ignition. Carbonization and manufacture of coke, caking index and coke quality. Coking process, cokeoven and byproducts; Origin, refining and distillation of crude petroleum, properties of liquid fuel – flash point, fire point, cloud point and pour point. Generation of producer gas, water gas, liquidified petroleum gas (LPG), gasifiers and gas analysis; Different types of industrial furnaces; batch and continuous furnaces and kilns, design and operation of different industrial furnaces and kilns, saggers, Fast firing technology, microwave furnaces. Fuel economy and thermal efficiency in the operation of furnaces; Sankey diagram, Regenerators and recuperators. Stack emission, chimney design, combustion calculation and environmental pollution, Measurement of temperature in furnaces- pyrometric cones, rings and bars and temperature controller; Combustion calculations of fuels; Material balance in ceramic processes. Batch and recipe calculation for refractories, glass, whitewares and cement. Energy Balance and flame temperature calculations. Combined material and energy balances.

Essential Reading:

1. R. M. Felder and R. W. Rousseau, ***Elementary Principles of Chemical Processes,*** Third Edition, Wiley., 2004.
2. S. Sarkar, ***Fuels and Combustion***, Orient Longman, Mumbai, 2nd Ed, 1990.
3. G. B. Remmy Jr., ***Firing of Ceramics***, World Scientific, 1994.

Supplementary Reading:

1. W. Trinks and M. H. Macwhinney, A. Shannon, R. J. Reed and J. R. Garvey, ***Industrial Furnaces***, 6th Ed., Wiley-Interscience, 2003.
2. R. A. Eppler and D. R. Eppler, ***Glazes and Ceramic Coatings,*** American Ceramic Society, 2000.
3. D. R. Dinger, ***Particle Calculations for Ceramists***, Dinger Ceramic Consulting Services, Clemson, US, 2001

CR 249	Materials Science and Engineering	3 credits [3-0-0]

Introduction to materials science and engineering, Bonding and structure of materials, Crystal Structure and Crystal Geometry: Space lattice; Unit cells; Crystal systems; Bravis lattices; Miller indices; Volume, planar and linear density unit cell calculations; Polymorphism; Crystal structure analysis, Crystalline Imperfections, defect chemistry, diffusions in Solids; Phase equilibrium and transformation, Solidification: Solidification of metals and single crystals; Solid solutions Physical properties of materials, Mechanical properties of materials, Electrical and semiconducting properties of materials, Dielectric and Magnetic properties of materials, Optical and thermal behaviour of materials, piezolectric and electro optic behaviour of materials, Superconducting materials, electrochemical properties etc; Engineering materials: alloys and inter metallics, ceramic materials, glasses, polymers and composites etc.

Essential Reading:

1. 1. W. F. Smith, ***Foundations of Materials Science and Engineering***, McGraw-Hill Professional, 2003.
2. 2. V. Raghavan, ***Materials Science and Engineering***, 4th Ed, Prentice-Hall of India Pvt. Ltd, New Delhi, 2004.

Supplementary Reading:

1. L. H. V. Vlack, ***Elements ofMaterials Science and Engineering***, 6th Edition, Prentice Hall, 1989
2. J. F. Shackelford and M. Meier, ***Introduction to Materials Science for Engineers***, Prentice Hall PTR, 2005.

CR 271	RAW MATERIALS ANALYSIS LABORATORY	2 credits [0-0-3]

Determination of Ca^{+2} and Mg^{+2} in water by EDTA method; Chemical analysis of limestone/dolomite; Complete analysis of Portland cement; Chemical analysis clay/magnesite/bauxite following Na_2CO_3/NaOH fusion; Determination of silica in quartz by HF treatment; Determination of very low-alkali content by flame photometer; Quantitative chemical analysis of Alumino-Silicate brick; Chemical analysis of ordinary soda-lime-silicate glass; Quantitative chemical analysis of tri-axial porcelain body; Chemical analysis of glaze frit.

CR 272	DRAWING OF REFRACTORY LINING & JOINTS	2 credits [0-0-3]

Study and drawing of different refractory bricks of standard shape; Study and drawing of non-standard shapes of refractory bricks; Drawing of brick wall and brick joints; Drawing of different parts of rotary kiln; Drawing of converter; Drawing of ladle; Drawing of Blast Furnace Trough Lining; Drawing of slide plates refractories; Drawing of sub entry nozzle; Drawing of monoblock stopper; Chimney calculation and drawing of chimney.

CR 273	CERAMIC WORKSHOP	2 credits [0-0-3]

Sieve analysis and particle size distribution of milled product; Verification of Rittinger's Crushing Law and determination of crushing efficiency of a Jaw Crusher; Validation of Bond's Law and determination of crushing efficiency of a Roller Crusher; Determination of angle of nip and maximum feed size for a Roll Crusher; Determination of critical speed and crushing rate of a Ball Mill; Study of Filter Press and preparation of filter cake; Determination of filtration rate of ceramic slurry; Study and operation of de-airing Pug Mill and preparation of extruded body; Operation of Counter Current Mixer and determination of mix consistency; Study and operation of Hydraulic Press and determination of bulk density.

CR 274	Ceramic Fabrication Laboratory	2 credits [0-0-3]

Determination of particle size and particle size distribution by Andreasen Pipette and Centrifuge; Determination of specific surface area of ceramic powder; Determination of intra-particle porosity of ceramic powder; Effect of additives on the rheology of oxide ceramic slurries; Preparation of slurry for slip casting of oxide ceramics and study of casting process; Determination of zeta potential and iso-electric point of ceramic slurry; Study of compaction behaviour of powder during dry pressing; Setting of plaster and determination of temperature rise and expansion of plaster during setting; Study of water to plaster ratio on physical properties of mould; Shaping of plaster of paris block.

CR 310	REFRACTORIES OR REFRACTORY	3 credits [3-0-0]

Classification of refractories, properties of refractories, packing of solid particles – monosized particles, bimodal mixtures of spheres, bimodal mixture of non spherical particles, ternary and multiple mixtures, continuous particle size distribution, particle interaction during dry compaction; Shaped Refractories: Alumino-silicate, high alumina, magnesia, silica, doloma, carbonaceous, Refractories; raw materials, processing, process quality control, Detailed analysis of phase diagrams with respect to the raw materials controlling the firing temperature and schedule; properties, microstructure applications; Composite refractories: alumina-carbon, magnesia-carbon, Spinel, alumina-silicon carbide- carbon, zirconia-carbon; Unshaped refractories; castables, gunning mass, ramming mixes, shotcreting mass, compositions/classifications, additives, manufacturing process, quality control, properties and applications; Properties and tests: Specification of different kinds of bricks, fusion point in relation to equilibrium diagram, PCE Test, HMOR, torsional creep properties and tests, Re-heat shrinkage, Spalling resistance, slag resistance; Reaction between refractories and glasses, heat transmission, behaviour of refractories in different environments, corrosion and failure of refractories, detailed analysis and interpretation of the refractories behaviour withrespect of microstructure.

Essential Reading:

1. J. H. Chesters, ***Refractories- Production and Properties***, The Iron and Steel Institute, London, 1973.
2. C. A. Schacht, ***Refractories Handbook***, CRC Press, 2004.
3. S. Banerjee, ***Monolithic Refractories: A Comprehensive Handbook***, Wiley-American Ceramic Society, 1998.

Supplementary Reading:

1. P. P. Budnikov, ***The Technology of Ceramics and Refractories***, Translated by Scripta Technica, Edward Arnold, The MIT Press, 4th Ed, 2003.
2. C. A. Schacht, ***Refractory Linings: Thermo-mechanical Design and Applications***, CRC Press, 1995.

CR 320	SCIENCE OF SINTERING	3 credits [3-0-0]

Diffusion: Mechanism of diffusion in solids, Ficks Laws, Nernst-Einstein equation, Random walk model, diffusion as a thermally activated process, thin film and error function solutions, diffusion distance, diffusion in ceramics, temperatures and imperfection related effects; Sintering: Driving force for sintering, solid state and liquid phase sintering, sintering models- mechanisms and kinetics. Grain growth and secondary recrystallization; Phase Transformation: Nucleation and Growth, spinodal decomposition; mechanism, thermodynamics and kinetics. Glass formation; Creep and Superplasticity: mechanisms andkinetics; Kinetics of Heterogeneous Reactions: Reactions with and between solids, calcination and dehydration reactions, particulateinteractions, coarsening, nonisothermal process kinetics.

Essential Reading:

1. W. D. Kingery, H. K. Bowen and D. R. Uhlmann, ***Introduction to Ceramics*** by 2nd Ed., John Wiley & Sons, NY.
2. M. N. Rahaman, ***Ceramic Processes and Sintering*** by Marcel Dekker.

Supplementary Reading:

1. P. G. Shewmon, ***Diffusion in Solids*** by McGraw Hill, NY.
2. H. Schmalzried, ***Solid State Reactions*** by Academic Press, NY, 1974

CR 322	GLASS TECHNOLOGY	3 credits [3-0-0]

Concept of the glassy state. The enthalpy temperature diagram. Fundamentals of Glass Formation: Structural and Kinetic Approaches. Nucleation and crystal growth. TTT diagram. Structural models of silicate and non silicate glasses, bridging and non-bridging oxygen, batch calculation, mixing and handling, viscosity, low and high temperature viscosity, temperature and compositional dependence of viscosity, glass transition temperature; thermal expansion and density; Glass composition and manufacturing process. Crystallization of glass – devitrification; glass-batch formulation. Mixing and handling of glass batch. Glass melting process, refining of glass. Decolourisation of glass. Reactions leading to glass formation. Fabricationprocess: Feeders, Colburn process, PPG process, Float process. Hollow ware and fibre glass; Quality control of glass, defects in glass: Stones, Seeds, Cords and Blisters, redoxequilibrium and chemical durability of glass, toughening and strengthening of glass; Optical properties of glass, optical glass, coloured glass including photochromic and electrochromic glass, solarization and photosensitive glasses, coating of glass. Non conventional glass making: Vapour quenching method, sol gel; General idea about glass-ceramic preparation.

Essential Reading:

1. A. Paul, ***Chemistry of Glasses***, 2nd Ed., Springer, 1990.
2. J. E. Shelby, ***Introduction to Glass Science and Technology***, The Royal Society of Chemistry, 2005.

Supplementary Reading:

1. P. W. McMillan, ***Glass Ceramics***, 2nd Ed., Academic Press, NY, 1979.
2. A. K. Varshneya, ***Fundamentals of Inorganic Glass***, Academic press, 1994.
3. H. Bachs and D. Krause, ***Low Thermal Expansion Glass Ceramics***, Springer, 2005.

CR 325	COMPUTATIONAL MATERIALS SCIENCE	3 credits [3-0-0]

Description of atomic interactions; Basics of the density functional theory, approximations in terms of pair potentials; embedded atom method and tight-binding. Material behaviour and computational model in nano-, micro-, meso- and macro-scales in the content of real materials-related problems (mechanical and thermodynamic properties, Phase transformation microstructure evolution during processing; Linear Elasticity Theory for Crystal Plasticity, Dislocation Statics and dynamics, Finite Element and Difference Methods at the Meso—Macroscale, Polycrystal Elasticity and Plasticity Models; introduction to computational modeling; molecular statistics; Molecular Dynamics: models of interatomic potentials, Equations of Motion for Atomic Systems: Application of Molecular Dynamics in Materials Science: Simulation of Brittle Fracture, Simulation of Interaction of Dislocations with Grain Boundaries; Monte Carlo Simulation and Integration and lattice dynamics, Interpretation of modeling in terms of structures using radial distribution function, Fundamentals of the Algorithm, Spin Monte Carlo methods, Thermo dynamic and statistical analyses, Simulation of Surface Segregation, Phase Transition, Thin Film Deposition

Application of computing and statistical fundamentals to solve Material Science and Engineering problems

Essential Reading:

1. D. Raabe, ***Computational Materials Science: The Simulation of Materials Microstructure and Properties***, Wiley-VCH, 1998.
2. M. Meyer and V. Pontikis, ***Computer Simulation in Materials Science: Inter-atomic Potentials, Simulation, Techniques and Applications***, Kluwer Academic Publishers, 1991.

Supplementary Reading:

1. K. Ohno, K. Esfarjani and Y. Kawazoe, ***Computational Material Science: from ab initio to Monte Carlo methods***, Springer, 1999.
2. J. R. Hill, L. Subramanian and A. Maiti, ***Molecular Modeling Techniques in Material Science***, CRC Press, 2005.

CR 327 INTERFACE SCIENCE & SOL-GEL PROCESSING 4 credits [3-1-0]

Thermodynamics of surface. Adsorption Isotherm. Physical aspects of interfaces, Grain boundary, Contact angle, Dihedral angle and Grain shape prediction, Concept of wetting. Structure of surface and interface; Colloids, Sols and gels, Types of colloids; attractive surface forces, stabilization of colloids, Electrostatic stabilization, charge development on the particle surface in aqueous medium, origin of electrical double layer, Iso-electric points and zeta potential,, Effect of electrolytes on double layer. Ion exchange capacity and exchange equilibrium, adsorption of polymers and steric stabilization, electrosteric stabilization, structure of consolidated colloids, rheology of consolidated colloids, Flocculation and de-flocculation phenomena, kinetics of flocculation; Wetting agents, Plasticizers, Foaming and antifoaming agents, Lubricants; Types of gel, sol-gel processing of aqueous silicates, metal alkoxides, hydrolysis and condensation, effect of pH on gelation, aging, drying and gel densification. Sol- gel preparation technique, single and multi-component gel, use of double alkoxides, applications of sol-gel processing

Essential Reading:

1. D. Myers, ***Surfaces, Interfaces and Colloids: Principles and Applications***, 2nd Edition, Wiley-VCH; 1999.
2. J. Reed, ***Introduction to the Principles of Ceramic Processing***, 2nd Ed., John Wiley & Sons, 1995.

Supplementary Reading:

1. M. N. Rahaman, ***Ceramic Processing***, CRC Press, Taylor & Francis Group, FL, 2007.
2. R. J. Pugh and L. Bergstrom, ***Surface and Colloid Chemistry in Advanced Ceramics Processing,*** CRC, 1994

CR 330 FUEL CELLS AND BATTERIES 4 credits [3-1-0]

Introduction; History, thermodynamics and electrochemical kinetics, fuel cell components and their impact on performance; Fuel cell systems: Proton exchange membrane fuel cell; Direct methanol fuel cells; Molten carbonate fuel cells; Polymer electrolyte fuel cells; solid oxide fuel cells; Fundaments of electrical and ionic conductivity, fast ionic conductors, defect chemistry, Electrolyte, material system, synthesis, properties, fabrication, applications; Anode, material system, synthesis, properties, fabrication, applications. Cathode, material system, synthesis, properties, fabrication, applications interconnects material system, synthesis, properties, fabrication, applications Special materials, material system, synthesis, properties, fabrication, applications. Stack design and fabrication techniques. Electorde polarization fundamentals, polarization kinetics. Testing and characterization of fuel cells and its components. Fuel processing and reforming of fuel; Batteries: general terms and characteristics, battery parameters, Fundamental aspects of battery system. Battery component, electrolyte, catode, anode, material system, synthesis, properties, fabrication, applications. Stack design and fabrication techniques. Testing and characterization of batteries and its components.

Essential Reading:

1. P. G. Bruce, ***Solid State Electrochemistry***, Cambridge University Press, 1997.
2. G. Hoogers, ***Fuel Cell Technology Handbook***, CRC Press, 2003.

Supplementary Reading:

1. H. A. Kiehne, ***Battery Technology Handbook***, CRC Press, 2003.
2. J. S. Newman and K. E. Thomas-Alyea, ***Electrochemical Systems***, Wiley-IEEE, 2004.
3. C. Julien and G. A. Nazri, ***SolidState Batteries: materials design and optimization***, Springer, 1994.

CR 331 WHITEWARE TECHNOLOGY 3 credits [3-0-0]

Raw materials, processing, properties, batch composition and the effect on the properties of whiteware bodies, effect of particle size distribution of kaolinite on plasticity and workability of clay. Rheology and properties of clay - water system, mechanism of plasticity, additives/binders, plasticizers, flocculants and deflocculants and slip properties; Classification of whiteware bodies, batch formulation Tri-axial bodies - porcelain, stoneware, earthenware, hotel ware, majolica, terra-cotta, bone china, parian-art ware, insulator, tiles, sanitary ware etc. Body preparation including the unit operations and fabrication processes. Application of granular mechanics to slip casting. Influence of particle size distribution on properties of fired whiteware bodies. Mould materials, mould and mould design; Fundamentals of drying and shrinkage. Firing of whiteware bodies, microstructure evolution during firing of whiteware bodies. Time, temperature and atmosphere effects on firing of whitewares, special firing techniques, Glaze structure, formulation, raw materials, batch calculation, preparation, slip rheology, application. colours, decoration firing. Testing of white ware bodies.

Essential Reading:

1. W. Ryan and C. Radford, ***Whitewares: Production, Properties and Quality Control,*** Pergamon Press, Oxford, 1987.

2. W. M. Carty, C. W. Sinton, ***Science of Whitewares II***, American Ceramic Society, 1999.
3. F. H. Norton, ***Fine Ceramics: Technology and Application***, McGraw Hill, NY, 1970.

Supplementary Reading:

1. R. A. Eppler and M. Obstler, ***Understanding Glazes,*** TheAmerican Ceramic Society, 2005.
2. V. E. Henkes, George Y. Onoda, W. M. Carty, ***Science of Whitewares***, The American Ceramic Society, 1996

CR 333	**HEAT TRANSFER AND FLUID FLOW**	**4 credits [3-1-0]**

Steady state and unsteady state conduction. Heat flow through composite walls, cylinders and spheres, Thermal resistances in series for ceramic materials. Convective heat transfer: Free and forced convection, application of dimensional analysis to convection problems. Radiation Heat Transfer black and grey bodies, Stefan-Boltzman's law, Kirchoff's law. Radiation through furnace openings. Combined effect of conduction, convention and radiation, overall heat transfer coefficient. Heat transfer through fluidized bed. Computation of heat loss from furnaces and kilns- sankey diagram. Heat transfer concept and selection of refractories. Fluid properties, density, viscosity, surface tension, compressibility. Classification of fluids: Newtonian and non-Newtonian fluids. Equation of continuity for compressible and incompressible fluid flow. Flow measurements: Venturimeter, Orifices, Pitot tube and Rotameter. Significance of Reynolds, Nussle's and Prandlt's Numbers; Euler's numbers, Archimedes number; Pressure drop in flow and pressure drop calculation in various cases, Flow through bends, Straight and bend pipes, Packed beds.

Essential Reading:

1. W. L. McCabe, J. C. Smith and P. Harriot, ***Unit Operations of Chemical Engineering***, McGraw Hill professional, 2005.
2. D. Q. Kern, ***Process Heat Transfer***, McGraw Hill International AucklandBogota, 1986.

Supplementary Reading:

1. R. H. Perry, D. W. Green and J. O. Maloney, ***Chemical Engineers' Handbook***; McGraw-Hill, 1999.

CR335	**INSTRUMENTAL CHARACTERIZATION**	**4 credits [3-1-0]**

Differential Thermal Analysis (DTA), Thermogrvimetric Analysis (TGA), Differential Scanning Calorimetry (DSC). Factors affecting the phase transformations - particle size, packing, heating rate, buoyancy effect. Thermal Conductivity, Dilatometry – basic principles, instrumentations and case study in ceramic applications. Study of sintering kinetics by dilatometry; Particle Size Analysis, Surface area and porosity – basic principle, data analysis; Spectroscopic method: UV-Visible, IR, FTIR and Raman – Basic principle, instrumentation and analysis of data; X-Ray Methods: x-ray generation, diffraction, Bragg law, Diffraction under ideal and non-ideal conditions, Scattering and structure factor. Principles of x-ray Diffractometer (XRD), x-ray data file and its analysis, indexing of crystal type. Chemical analysis by x-ray fluorescence (XRF) – Wave length and energy dispersive XR; Optical microscopy - light optics, microscope components, possibilities and limitations. Scanning Electron Microscopy - Optics and performance of a SEM, Image interpretation, crystallographic information in a SEM, analytical microscopy. Transmission Electron microscopy - construction and operation of a TEM, electron diffraction, Image interpretation. Techniques of sample preparation for TEM and SEM methods. Electron Beam Microprobe Analysis.

Essential Reading:

1. R. F. Speyer, ***Thermal Analysis of Materials***, CRC Press, 1994.
2. B. D. Cullity, ***Elements of X-ray Diffraction***, Addison Wesley Publishing Company; 2nd edition 1978.
3. P. J. Goodhew, J. Humphreys and R. Beanland, ***Electron Microscopy and Analysis***, Third Edition, Taylor & Francis, 2001.

Supplementary Reading:

1. H. P. Klug and L. E. Alexander, ***X-ray Diffraction procedures for Polycrystalline and Amorphous Materials***, 2nd Edition, John Wiley, 1974.
2. D. A. Skoog, F. J. Holler and T. A. Nieman, ***Principles of Instrumental Analysis***, 5th Ed., HartcourtCollege Publishers, 1998.

CR 336	**CEMENT TECHNOLOGY**	**4 credits [3-1-0]**

Introduction to hydraulic materials. Classification of Cement, Chemistry of hydrated and anhydrous cement compound. Manufacturing of Portland cement; Dry, Semi-dry, wet and semi-wet process, Cement grinding, Testing of cement, Cement compounds and their phase relations, Cementing qualities of cement phases, The burning of Portland cement, Constitution of Portland cement, Phase equilibrium conditions of clinker crystallization, Calcia-Alumina-Silica system, Clinker constitution and cooling process, refractories used in the rotary kiln, Role of free magnesia and free lime in the clinker, hydration of cementing phases and Portland cement, theories and mechanism of cement setting and hardening, Action of acid water and sulphate waters on Portland cement, Steam-curing of

Portland cement. Special Cement and cement additives, Blast Furnace slag- and high alumina cement. Concrete: Types, Method of production and Properties of concrete, Alkali-aggregate reaction, Electrical and fire resistance of cement and concrete. Pollution control in cement industries.

Essential Reading:

1. P. Hewlett, ***Lea's Chemistry of Cement and Concrete,*** Fourth Edition, Butterworth Heinemann; Fourth edition, 2004.
2. H. F. W. Taylor, ***Chemistry of Cement,*** Thomas Telford, 1997.

Supplementary Reading:

1. E. M. Gartner and M. Uchikawa, ***Cement Technology***, The American Ceramic Society, 1994.
2. K. E. Peray, ***Cement Manufacturer's Handbook***, Chemical Publishing Company, 1979

CR 339	Ceramics in Electronic Applications	3 credits [3-0-0]

Introduction, elementary solid state science, electrical conduction, defect and defect chemistry, charge displacement process. Ceramic conductors: high temperature heating elements and electrodes, ohmic resistors, varistors, thermistors – PTC, NTC, fuel cells and batteries, sensors, materials system, powder synthesis, processing, properties, devices and application. Fundamentals of superconductivity, theories of superconductors, materials system, synthesis, processing, properties and application; Dielectric and insulators, fundamentals of capacitors, classification of dielectric matrials, materials system, low permittivity, medium permittivity and high permittivity, Powder synthesis, processing, properties, fabrication and application. Capacitor designs, processing; Fundamentals of piezoelectricity, materials system, synthesis, processing, properties, devices and application. Fundamentals of pyroelectricity, materials system, synthesis, processing, properties, devices and application. Electro-optic fundamentals, materials system, synthesis, processing, properties, devices and application; Fundamentals of magnetism, Magnetics ceramics basic concepts, model ferrites: spinel ferrites, hexaferrites, garnets, properties influencing magnetic behavior, soft ferrites, hard ferrites, microwave ferrites, Preparation of ferrites, rawmaterials, mixing calcinations and milling, sintering, post sintered processing, applications.

Essential Reading:

1. R. C. Buchanan, ***Ceramic Materials for Electronics: processing, properties and applications***, Marcel Dekker, NY, 1986.
2. L. M. Levinson, ***Electronic Ceramics: properties, device and applications***, CRC Press, 1987.

Supplementary Reading:

1. A. J. Moulson and J. M. Herbert, ***Electroceramics: Materials, Properties and Applications***, Springer, 1990.
2. B. Jaffe, W. R. Cook, H. Jaffe and H. L. C. Jaffe, ***Piezoelectric Ceramics***, R. A. N Publishers, 1990.

CR 341	PHYSICAL CERAMICS	4 credits [3-1-0]

Mechanical Properties: Concept of strength and its relation with fundamental parameters, plastic deformation, viscous flow, creep, Fracture of materials; Thermal Properties: Thermal expansion, thermal shock, annealing and chemical strengthening, specific heat and heat capacity, thermal conduction process; Electrical Properties: Electrical, electronic and ionic conduction phenomena in crystals, Fast ionic conductors, glasses and non-stoichiometric compounds. PTCR, NTCR, Varistors, thermisters etc; Dielectric Properties: Dielectric loss of crystals and glasses, dielectric strength, piezoelectric and ferroelectric ceramics; Magnetic Properties: Concept of magnetic phenomena in solids. Structure and magnetic properties of spinel ferrites, rare-earth garnets, ortho-ferrites and hexagonal ferrites with special reference to their microstructure; Optical Properties: Refractive index and dispersion, reflectance, opacity and translucency, absorption and colour from modern concepts in crystalline and vitreous ceramic systems.

Essential Reading:

1. W. D. Kingery, H. K. Bowen and D. R. Uhlmann, ***Introduction to Ceramics***, 2^{nd} Ed., John Wiley & Sons Pte Ltd., Singapore, 1991.
2. Y. M. Chiang, D. Birnie III and W. D. Kingery, ***Physical Ceramics: Principles for Ceramic Science and Engineering***, Wiley, 1996.

Supplementary Reading:

1. M. Barsoum, ***Fundamentals of Ceramics***, CRC Press, 2002.
2. L. V. Azaroff, ***Introduction to Solids***, Tata McGraw Hill, 1977.

CR 344	MICROSTRUCTURAL DESIGN IN CERAMICS	3 credits [3-0-0]

Characteristic of microstructure; Quantitative analysis; Properties and factors affected by microstructure; microstructural aspects of sintering and grain growth, microstructural variables; Mechanical, thermal, optical properties and the effect of microstructure; High temperature degradation; Wear behaviour; Techniques for characterizing ceramic microstructure. Resolution and its implications for routine microscopy, Optical microscopy, scanning electron microscopy, stereoscopy and stereology. Preparation of ceramic samples for microscopy. Fine powders and granulates; microstructural characterization of green bodies- sample preparation for SEM and TEM study; Dense fired ceramics, porous ceramics, microstructural maps of sintered body, polished surface and fractured surface microstructure, common pore structure in ceramic bodies, pore morphology and properties, quantitative estimation of different phases and grain size; study and interpretation of wetting behaviour, grain boundary film, crystalline interface boundaries, crystalline interphase boundaries, dislocations in the sintered body by SEM and TEM; microstructure of different types sintered ceramic bodies: Triaxial whiteware bodies, refractories, clay products, glass, glazes and enamels, glass ceramics, advanced and special ceramics.

Essential Reading:

1. W. E. Lee and W. M. Rainforth, ***Ceramic Microstructures: Property Control by Processing***, First Edition, Springer, 1994.

Supplementary Reading:

1. W. D. Kingery, H. K. Bowen and D. R. Uhlmann, ***Introduction to Ceramics***, 2nd Ed., John Wiley & Sons Pte Ltd., Singapore, 1991.

CR 346	NANOCERAMICS	4 credits [3-1-0]

Introduction to nanotechnology: Formation of nanomaterials by size reduction: Amorphisation by milling, molten drop impingement and limitations of milling for ceramic materials. Gas phase processes for nanomaterial synthesis: Nanosized clusters of elementary particles and ceramic materials. Condensed phase processes for nanomaterial synthesis; Manufacture of nanostructured materials (densification, nanocomposites). Determination of structure and chemical, mechanical, magnetic, electrical and optical physical properties of nanomaterials. Methods for determination of particle size, porosity, specific surface, chemical and supramolecular structures at the nanometric level. Proximal microscopies (AFM and STM), nanolithography and nanofabrication; technological applications of nanomaterials- super-plasticity, plastic flow processing of ceramics; ultra-pure and biocompatible ceramics; gas sensors; transparent ceramic coatings, diamond-like coatings, the fullerenes and carbon nanotubes, nano magnets for sensors and high density data storage, spin-tronic devices, nanotechnology for biological system & bio-sensor applications.

Essential Reading:

1. M. Wilson, K. Kannangara, G. Smith and M. Simmons, ***Nanotechnology: Basic Science and Emerging Technologies***, CRC Press, 2002.
2. R. Freer, ***Nanoceramics: A British Ceramic Proceedings***. British Ceramic Society, 1993.
3. A. S. Edelstein, R. C. Cammarata, ***Nanomaterials: synthesis, properties and applications,*** CRC Press, 1998

Supplementary Reading:

1. M. A. Ratner and D. Ratner, ***Nanotechnology: A Gentle Introduction to the Next Big Idea***, Prentice Hall PTR, 2003.
2. G. Cao, ***Nanostructures and Nanomaterials: Synthesis, Properties and Applications***, ImperialCollege Press, 2004.
3. 3. H. G Rubahn, ***Basics of Nanotechnology,*** 3rd Edition, Wiley, 2008

CR 348	Introduction to Engineering Ceramics	3 credits [3-0-0]

Definition of engineering ceramic materials. Engineering ceramics generally considered in the ceramics family- natural ceramics, polycrystalline ceramics fabricated by sintering, glass, glass-ceramics, single crystals of different ceramics and artificial gems. Engineering with ceramics: high temperature applications, ceramics in metal processing, glass production, industrial processes, ceramics in heat engines, wear and corrosion resistant applications-ceramics in seals, valves, pumps, bearings, thread guides, ceramics in paper making, ceramics as cutting tool inserts, super hard abrasives; Electrical applications of ceramics- dielectric ceramics, semiconductors, conducting ceramics, ceramic superconductors. Magnetic ceramics, opotical and opto-electronic applications of ceramics. Ceramic composites- particulate, whiskers, fibre reinforced ceramics. Medical applications of ceramics, ceramics in efficient use of energy and pollution control. Design with ceramics, design considerations- reliability requirement, fabrication limitation and cost consideration. Design approaches – empirical, deterministic and probabilistic design, Weibull statistics and failure analysis. Advantages and limitations of probabilistic design, linear elastic fracture mechanics approach and combined approach

Essential Reading:

1. J. B. Wachtman Jr., ***Treatise on Materials Science & Technology, Structural Ceramics Vol- 29,*** Academic Press Inc., New York, 1989.
2. D. W. Richerson, ***Modern Ceramic Engineering: Properties, Processing, and Use in Design,*** 3rd ed, CRC Press, 2005

Supplementary Reading:

1. S. Hampshire, ***Non-Oxide Technical and Engineering Ceramics***, Elsevier Applied Science, London, 1986.
2. W. E. Lee and W. M. Rainforth, ***Ceramic Microstructures: Property Control by Processing***, First Edition, Springer, 1994.

CR 370	REFRACTORIES TECHNOLOGY LABORATORY	2 credits [0-0-3]

Determination of packing density of one component system of various particle sizes; Determination of packing density of two component system having various size ratios; Recipe calculation and recipe making for refractory mix; Study of compaction response behaviour of refractory mix; Shaping of refractory brick by dry pressing/hand moulding method; Determination of porosity and density of the prepared refractory brick; Determination of crashing strength of refractory bricks; Study of thermal shock resistance and PLCR of refractory brick; Determination of MOR and HMOR of refractory brick; Vibrocasting of supplied castable and study of cured property; Effect of casting parameter on the properties of cast refractories; Study of strength development of castable with temperature.

CR 371	HIGH TEMPERATURE PROCESSING LABORATORY	2 credits [0-0-3]

Calibration of thermocouple and determination of temperature profile of the furnaces; Effect of process parameters on the response behaviour of PID controller; Calibration of PID temperature Controller; Study of isothermal sintering behaviour of ceramic materials; Study of non-isothermal sintering behaviour of ceramic materials; Study of decomposition kinetics of a material from its isothermal weight loss behavior; Study of phase transformation kinetics from differential thermal analysis; Study of the heating rate on constant rate heating densification behavior; Study of binder burnt out behaviour by TGA; Study of recystallization behaviour of materials.

CR 372	GLASS TECHNOLOGY LABORATORY	2 credits [0-0-3]

Batch calculation and preparation of soda-lime-silicate glasses; Fabrication of plate glass and annealing; Determination of glass transition temperature of the processed glass; Effect of refining agents during preparation of glasses; Fabrication of hollow glass ware by blowing techniques; Study of chemical durability of glasses using Flame Photometer; Batch calculation and fabrication of different coloured glasses; Determination of refractive index and colour concentration of glass; Determination of density of glass by non-destructive methods; Detection of strain in glass and annealing schedule; Determination of CTE of commercial glasses; Study of Littleton softening point of glass.

CR 373	WHITEWARE TECHNOLOGY LABORATORY	2 credits [0-0-3]

Design and drawing of model and mould; Shaping of a pre-designed plaster model; Fabrication of pre-designed slip casting mould; Fabrication of model using Jigger and Jolly; Determination of plasticity and Plasticity Index; Determination of drying sensitivity of a green body; Study of drying curve and critical moisture content of a green body; Determination of vitrification range of a whiteware body; Determination of deffloculant demand curve of slip; Study of slip casting behavior; Study of glaze-body fit by dilatometer; Determination of flow limit of glaze; Finishing, drying and glazing of cast wares; Crazing resistance of glazed article.

CR 374	CERAMIC PRODUCT DEVELOPMENT LABORATORY	2 credits [0-0-3]

This is a project based laboratory where the students are required to develop a specific ceramic product having a given range of different properties. On the basis of the supplied end properties and the possible application area, the student will choose the raw material and the powder processing route, the green shape fabrication method. The developed green ceramic product needs to be sintered for evaluation of product property. The statistical analysis of the evaluated properties should be carried out to judge the product reliability.

CR 375	Ceramic Characterization Laboratory	2 credits [0-0-3]

Study of thermal decomposition behaviour of dolomite / limestone/ magnesite; Study of phase transition in quartz by DTA; Weight loss behaviour of dolomite, magnesite and limestone by TGA; Study of thermal expansion behaviour and determination of thermal expansion coefficient of ceramic product; Determination of thermal hysteresis of zirconia by dilatometric method; Study and operation of x-ray diffractometer; Indexing of cubic crystal system and determination of its lattice parameter; Determination of lattice parameter of tetragonal crystals; Determination of crystallite size from x-ray line broadening; Study of data acquisition and processing for obtaining an x-ray profile; Phase identification using software; Determination of a calibration curve for quantitative estimation of two-phases in a mixture.

CR 376	CEMENT TECHNOLOGY LABORATORY	2 credits [0-0-3]

Preparation of Portland cement in the laboratory; Determination of consistency of cement; Study of initial and final setting of cement by Vicat apparatus; Determination of soundness of cement Le Chatelier method; Making and curing of cement mortar; Compressive strength of cement mortar fine with ageing time; Determination of surface area of cement by Blain Air Permeability apparatus; Determination of fineness modulus and grain size distribution of fine aggregate; Effect of casting process parameters on the properties of cement mortar; Quantitative chemical analysis of cement; Effect of admixture on cement mortar; Study of the durability of cement mortar

CR 377	Ceramic Equipment Design Laboratory	2 credits [0-0-3]

Design of tunnel kiln brick lining; Design of rotary kiln brick lining; Design of electrically heated laboratory furnace; Design of spray drier/spray pyrolyzer heating chamber; Design of L-D converter lining; Design of Ladle lining

CR 411	Advanced Ceramics	4 credits [3-1-0]

Introduction and classification of Structural Ceramics, Brief review of Griffith theory of fracture, toughness, statistical nature of strength Alumina and alumina ceramics Crystal structure, phases, types of alumina, properties and its relation to microstructure, importance and application. Zirconia Ceramics Crystal structure and polymorphic modifications, Transformation Toughening; different system in zirconia, application. Composites: strengthening and toughening mechanisms, composite fabrication. Composites of some oxides and nonoxides. Classification of non-oxideceramics, siliconcarbide, siliconnitride Sialon, Tungsten Carbide, Boron Carbide, Boron Nitride, Carbon and Graphite, phase diagrams, processing, sintering and properties. Abrasives; natural and synthetic; properties, applications andperformances; Semiconductor, electronic, ionic conductors and fast ion conductors; defects influoride type andperovskite oxides; conduction process and transference number; electronic conduction in oxides; semiconductor - metal transition; Ionic conduction in oxides; fast –ion conductors; resistors and varistors, ceramic capacitors, piezoelectric and electro-optic ceramics, Super conductivity: basic principles; materials; synthesis and applications; Magnetic Ceramics: Introduction; types of magnetism: magnetic anisotropy; magnetostriction; domains and magnetization processes; magnetic Materials: soft and hard; synthesis; characterization and applications, ferro-electricity in capacitor technology, recent developments in this area.

Essential Reading:

1. J. B. Wachtman Jr., ***Structural Ceramics, Treatise on Materials Science & Technology Vo l- 29***, Academic Press, New York, 1989.
2. W. E. Lee and W. M. Rainforth, ***Ceramic Microstructures: Property Control by Processing***, Springer, 1994.
3. R. C. Buchanan, ***Ceramic Materials for Electronics: Processing, properties and applications***, Marcel Dekker, 1986.

Supplementary Reading:

1. E. Dorre and H. Hubner, ***Alumina: Processing, Properties and Applications***, Springer- Verlag, Berlin Heidelberg, 1984.
2. A. J. Moulson and J. M. Herbert, ***Electroceramics: Materials, Properties and Applications***, Springer, 1990.

CR 415	BIOCERAMICS	3 credits [3-0-0]

Introduction to biomaterials, bio-ceramics as implant in human body, Physics of bone and structure of tooth, Cortical bone versus Trabecular bone structure. Different type of biomaterials: Metal and alloys, Ceramics, Polymers and composites; Bio-glass and A/W Glass ceramics, Hydroxyapatite, Bioactivity and bone bonding, porous hydroxyapatite and study of bio-compatibility; Composite implant materials: mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement. Polymers filled with osteogenic fillers. Host tissue reactions; Properties of biomaterials: Bulk properties – mechanical, biological and chemical properties; Surface properties – Surface roughness and surface characterization. Testing of biomaterials/Implants: ***In vitro*** testing (Mechanical testing): tensile, compression, wears, fatigue, corrosion studies and fracture toughness. ***In-vivo*** testing (animals): biological performance of implants. ***Ex-vivo*** testing: ***in vitro*** testing simulating the ***in vivo*** conditions. Standards and specifications of implant materials, recent developments in this area.

Essential Reading:

1. L. L. Hench and J. R. Jones, ***Biomaterials, Artificial Organs and Tissue Engineering***, Taylor & Francis 2007
2. J. F. Shackelford, ***Advanced Ceramics (vol. 1) Bioceramics***, Gordon and Breach Science Publishers, New York, 1999.

Supplementary Reading:

1. A. Wereszczak, M. Mizuno and E. L. Curzio, ***Advances in Bioceramics and Biocomposites II,*** John Wiley & Sons, 2007.

CR 416 APPLICATION OF REFRACTORIES 4 credits [3-1-0]

Review of metallurgical processes; Identification of different refractory linings for primary and secondary steel making operations, Hot repairing – Materials, Repairing techniques; Future trends in utilization of refractories towards efficient lining for steel making; Coke oven refractories, Blast furnace refractories, trough refractories, taphole clay, refractories for cooling and heat saving in blast furnaces, Refractories for steel making, Ladle refractories, Continuous casting refractories: Materials, Production, Properties, Applications and Future trends; Use of non-oxide ceramic materials in ferrous and non-ferrous industries. Refractories in cement industries. Refractories in glass industries. Direct bonded mag-chrome aggregates and refractories for Aluminium, Copper, Zinc and Petrochemical Industries. Standardization, testing – including non – destructive testing. New generation slide gate refractories with improved performance, Plant trial performance ofnon shaped and advanced refractories developed using surface chemistry, thermo-mechanical considerations for refractory linings, refractories for the refineries and circulating fluid beds, plasma processing of refractory aggregates, coating techniques for improving the oxidation resistance of graphite. Recent developments in the application of refractories, recent developments in this area.

Essential Reading:

1. J. H. Chesters, ***Refractories- Production and Properties***, The Iron and SteelInstitute, London, 1973.
2. R. Amavis, ***Refractories for the Steel Industry***, Elsevier Applied Science, Springer, 1990.

Supplementary Reading:

1. S. C. Caniglia and G. L. Barna, ***Handbook of Industrial Refractories Technology: Principles, Types, Properties and Applications***, William Andrews Inc, 1992.
2. S. Banerjee, ***The Changing Refractories Industry: New Technologies, Materials and Markets***, Business Communication Co, 1999.

CR 417 UNSHAPED REFRACTORIES 4 credits [3-1-0]

Introduction to monolithic refractories, advantages and disadvantages; classifications based on application techniques, chemical constituents and purity; raw materials and their selection, particles size distribution, discrete and continuous particle size distribution, Furnas, Andreassen-Andersen and Dinger-Funk model; different bonding systems, CaO-Al2O3 system, hydration of calcium aluminates, bonding mechanism of different binders, various additive systems; refractory castable and details of CCC, LCC, ULCC, NCC, SFC; other monolithics, like mortar, gunning mass, spraying mass, ramming mass, etc; machinery and equipments for making unshaped refractories, batch preparation, mixing, processing and manufacturing techniques; installation techniques and application; properties and specialties of different castable systems, like alumina, alumina - magnesia, alumina spinel, magnesia, magnesia carbon, etc

Essential Reading:

1. C. A. Schacht, ***Refractories Handbook***, CRC Press, 2004.
2. S. Banerjee, ***Monolithic Refractories: A Comprehensive Handboo***k, Wiley-American Ceramic Society, 1998.
3. Subrata Banerjee, ***Thomas Abraham, The changing refractory industry: new technologies, materials, and markets***, Business Communications Co., 1999.

Supplementary Reading:

1. Stephen C. Carniglia, ***Hand book of industrial Refractories technology***, Principles, Types, Properties and Applications Noyes Publications USA 1992.
2. Hiemenz PC. ***Principles of Colloid and Surface Chemistry***. 2d ed. New York: Marcel Dekker, 1986.

CR 418 Nanomaterials 3 credits [3-0-0]

Introduction to Nanostructured materials, Low-dimensional structures: Nano clusters & Nano crystals, superparamagnetic materials, nanomagnetic composite materials, Magnetic nanostructured materials, Nanoscale magnetism of fine particles of transition metals, alloys and oxides, Survey of materials and scaling with respect to different types of nanomaterials- metals, ceramics, semiconductors, polymers, structural materials and functional materials; Rate- controlling mechanisms and diffusion. Nucleation-classical nucleation theory, clusters and nucleation rates; characterization of nanostructured materials, different synthesis techniques; Ultrafine powders and communition. Nanocomposites, Thin films and Coatings. Sol-gel processing of different types of materials and their consolidation. Monoliths, films, membranes; Gas phase synthesis, photolithography; Nanotechnology and MEMS, nano magnets for sensors and high density data storage, carbon nanotube, spin-tronic devices, nanotechnology for biological system & bio-sensor applications, recent developments in this area.

Essential Reading:

1. C. N. R. Rao, A. Müller and A. K. Cheetham***, The Chemistry of Nanomaterials: Volume 1, Synthesis, Properties and Applications***; Wiley-VCH, 2006.
2. C. N. R. Rao, A. Müller and A. K. Cheetham, ***The Chemistry of Nanomaterials: Volume 2, Synthesis, Properties and Applications***, Wiley-VCH, 2006.

Supplementary Reading:

1. G. Cao, ***Nanostructures and Nanomaterials: Synthesis, Properties and Applications***, ImperialCollege Press, 2004.
2. R. Booker and E. Boysen, ***Nanotechnology: The fun and easy way to explore the science of matter's smallest particles,*** Wiley Publishing Inc. 2005

CR 419	Biomaterials for Artificial Implants	3 credits [3-0-0]

Bio-compatability-definition and issues, introduction to biological environments, function and degradation of materials in vivo- swelling and leaching, corrosion and dissolution, reactions of biological molecules with bio-material surfaces, mechanics of materials- deformation and failure, friction and wear. Biological effects of implants- inflammatory process, adaptation, allergic foreign- body response; Surface chemistry of materials- surface energy, contact angle, critical surface tension, electrokinetic theory; Biomaterials, types- metals, polymers- hydrogels, polymer degradation, resorbable polymers, sutures, drug delivery, dialysis membranes. Ceramics, - dense ceramics, porous ceramics, bio-active ceramics, resorable ceramics, composites - structure and properties; processing of bio-materials. Coated Hydroxyapatite – need for coating, type of coating – Plasma sprayed coating, bio-mimetic coating. Characterization of biomaterials; in-vitro and in-vivo testing, Polymeric biomaterials – naturally occurring polymeric biomaterials, synthetic non bio-degradable and bio degradable polymers, polymer matrix composite biomaterials; Application of bio-materials- dental implants, orthopaedic implants, soft tissue application, Tissue engineering- biomaterials for tissue engineering, recent developments in this area.

Essential Reading:

1. S. V Bhat, ***Biomaterials***, Kluwer Academic Publishers, 2002.
2. J. B. Park and J. D. Bronzino, ***Biomaterials: Principles and Applications***, CRC Press, 2002.

Supplementary Reading:

1. D. L. Wise, D. J. Trantolo, D. E. Altobelli, M. J. Yaszemski and J. D. Gresser, ***Human Biomaterials Applications***, Humana Press, 1996.

CR 420	GLASS CERAMIC TECHNOLOGY	4 credits [3-1-0]

Fabrication and properties of Glass ceramics. Crystallization of glass: Homogeneous and heterogeneous nucleation, Growth. Binary (Mullite) and ternary (Mullite, Hexacelsian, Celsian-Rutile) glass ceramics. Phase separation. Control of mechanical, thermomechanical, electrical, optical properties through microstructure development in glass ceramics. Nanocrystalline microstructure. Surface strengthening– thermal strengthening and chemical strengthening of glass ceramics. Technical application of glass ceramics: Structure, composition and properties of glass ceramic used in Radome, Photosensetaitve materials, Machinable glass ceramics, Magnetic Memory Disk. Household application of glass ceramics : Decorative glass ceramics, High – Quartz and Keatite- type alumino- silicates, composition of ceramic colours glass ceramic cook top panels. Precision Optical applications: low thermal expansion glass ceramics, large casting technology, dimensional stability, transparent glass ceramic, thin walled cylinders, reflective optics, laser gyroscopes, light weight mirrors, Radiation stability technology, Refractory glass ceramics, Glass ceramics in biomedical application.

Essential Reading:

1. M. H. Lewis***, Glass & Glass Ceramics***, Chapman & Hall, London, 1989.
2. W. Holand***, Glass Ceramic Technology***, The American Ceramic Society, 2002

Supplementary Reading:

1. Paul, ***Chemistry of Glasses***, Chapman and Hall, 2nd Ed., 1990.
2. P. W. McMillan, ***Glass Ceramics***, Academic Press, 2nd Ed., NY, 1979.
3. H. Bachs and D. Krause, ***Low Thermal Expansion Glass Ceramics***, Springer, 2005

CR 421	GLASSES FOR ADVANCED TECHNICAL APPLICATIONS	4 credits [3-1-0]

Properties of technical glasses, Effect of glass composition on mechanical, optical and electrical properties of glass. Properties and processing of Chemical resistant glass, heat resistance glass, CRT glass, Neutral glass, Glass electrodes, Low dielectric loss glass, Eutectic glass. Glass metal sealing. Processing and properties of Glass Fibres for Insulation and Reinforcement. Hard glass. Theoretical strength of glasses. Different parameter controlling strength of glass. Glasses for Plasma Display Panels. Chalcogenide and Halide and oxy-halide glasses. Properties of Photonic Glass. Gradient index glass : Application, properties and design. Properties of laser glasses. Processing of Optical fiber. Fiber Gratings. Glass Fibers for High Power Lasers: Fundamentals and applications: Nonlinear optical glass and Magneto-optical glass

Essential Reading:

1. M. H. Lewis***, Glass & Glass Ceramics***, Chapman & Hall, London, 1989.
2. W. Holand, ***Glass Ceramic Technology***, The American Ceramic Society, 2002

Supplementary Reading:

1. M. Yamane, ***Glasses for Photonics***. Chembridge University Press 2000.
2. P. W. McMillan***, Glass Ceramics***, Academic Press, 2nd Ed., NY, 1979.
3. H. Bachs and D. Krause, ***Low Thermal Expansion GlassCeramics***, Springer, 2005

CR 422 CERAMIC EQUIPMENT DESIGN 3 credits [3-0-0]

Design of Ball Mill, Design of Laboratory Furnace, Design of cement rotary kiln, Design of tunnel kiln for refractory industry, Design of tunnel driers, Design of humidity control drier, Design of LD converter lining, Design of Electric Arc Furnace lining, Design of Ladle lining, Design of Spray Drier.

Essential Reading:

1. S. M. Walas, ***Chemical Process Equipment: Selection and Design***, Butterworths -Heinemann, Butterworths, 1988.

Supplementary Reading:

1. H. J. Sandler, and E. T. Luckiewicz, ***Practical Process Engineering:*** A Working Approach to Plant Design, McGraw Hill Book Company, 1987.
2. V. C. Davis, ***Calculation in Furnace Technology***, Pergamon Press ltd, 1970.

CR 424 COMPOSITE MATERIALS 3 credits [3-0-0]

Composites- Definition, Classification and Importance, design of composite materials, the concept of load transfer, Glass, ceramic and carbonfibres, silicon carbide, alumina and alumino-silicate fibres. Common ceramic matrix material and their properties, interfaces in composites, interaction at the interface. Types of reinforcement: continuous fibre, short fibre, whisker; Ceramic Matrix composites: fibre packing arrangement, fabrication, properties, interface reaction, toughness; specific examples - Alumina -silicon carbide, Mullite- Zirconia, polymer-PZT composites, metal composites, layered composites- composite processing, densification and application; properties of composites: Density, Mechanical properties, mechanism of load transferfrom matrix to fibre, elastic deformation of laminates, variation of lamina properties with orientation, tensile and compressive strength and failure mechanism of long and short fibre composites, toughness of composites and sub-critical crack growth, thermal behaviour of composites debonding, fibre pull out, delamination fracture. Application of composites. Recent advances in composite technology, recent developments in this area.

Essential Reading:

1. G. F. Carter and D. F. Paul, ***Materials Science and Engineering***, ASM International, 1991.
2. J. F. Shackelford and M. Meier, ***Introduction to Materials Science for Engineers***, Prentice Hall PTR, 2005.

Supplementary Reading:

1. F. L. Matthews and R. D. Rawlings, ***Composite Materials: Engineering and Science***, Woodhead Publishing, 1999.
2. K. K. Chawla, ***Composite Materials: Science and Engineering***, Springer, 2001.

CR 426 TRIBOLOGY OF MATERIALS 3 credits [3-0-0]

Introduction: Different types of materials and applications, surface characterization (Physico – chemical characteristics of surface layers) Surface visualization, Geometry of non – conforming surfaces (analysis and measurement of surface roughness), Surface and subsurface stress distributions and Hertzian contact; Contact between solid surfaces; Adhesion Friction; Testing, Frictional behavior (Solid – solid contact, liquid mediated contact), Friction mechanism of metals, ceramics and polymers, solid lubricants. Thermal properties of sliding surfaces; Classification of wear and wear testing, role of humidity; the various modes of wear: adhesive, delamination, fretting, abrasive, erosive, corrosive, oxidizing (mild and severe), melt and the wear-mechanism maps, types of particle present in wear debris; Surface Engineering Methods to reduce wear, Electrolytic, Spraying, Hard-facing, Chemical Vapour Deposition (CVD), Plasma Vapour Deposition (PVD), Mechanical methods, Surface melting and Thermo chemical treatments; Lubrication: Solid lubricants, Liquid lubricants, Fluid film lubrication, Introduction to Elasto-Dynamic (ED) and Elasto- Hydro Dynamic (EHD) Lubrication, Mixed and Boundary lubrication, micro and nano tribology, solution of tribological problems, recent developments in this area.

Essential Reading:

1. B. Bhushan, ***Principles and Applications of Tribology***, Willey –IEEE, 1999.
2. M. Hutchings, ***Tribology: Friction and Wear of Engineering Materials***, Edward Arnold, 1992. (Original from the University of Michigan Digitized 6 Dec 2007)

Supplementary Reading:

1. K. C. Ludema, ***Friction***, ***Wear, Lubrication: A Textbook in Tribology***, CRC Press, 1996.
2. R. D. Arnell, P. Davies, J. Halling, and T. Whomes, ***Tribology Principles and Design Applications***, MacMillan, 1991(Original from the University of Michigan Digitized 6 Dec 2007)

CR 433	SENSOR TECHNOLOGY	3 credits [3-0-0]

Overview, definition and classifications of sensors, principles of ceramic sensors, physical-chemical and technological principles of ceramic sensors: basic concepts, technological principles, operating principles of porous ceramic sensors. Ceramic humidity sensor: classification, basic parameters and characteristics, testing and stabilization of humidity sensor, control of the sensitivity of ceramic humidity sensors. Ceramic gas sensor: classification, parameters and characteristics of resistive gas sensor, selectivity and sensitivity of gas sensor, operating principles, reducing gas sensor, alcohol sensor, odor and product quality sensor, oxygen sensor, ceramic sensor for other gases, manufacturing of gas sensor. Ceramic temperature sensor: NTC thermistors, PTC thermistors, CTR thermistors, capacitive ceramic temperature sensors. Ceramic pressure sensors. Multifunctional ceramic sensors; Humidity-gas and Temperature-humidity ceramic sensors, Temperature-Humidity-Gas ceramic sensors. Application of ceramic sensors Flow Sensor, Acoustic Sensor, Magnetic field sensor; Chemical Sensor; Biosensors: Origin of biosensor, transduction mechanism of biosensor, application range of biosensor and future prospects; Sensor Instrumentation; MEMS based sensor, Nanotechnology in Sensor applications, recent developments in this area.

Essential Reading:

1. T. G. Nenov and S. P. Yordanov, ***Ceramic Sensors: Technology and Applications***, CRC Press, 1996.
2. S. Soloman, ***Sensors Handbook***, McGraw-Hill Professional, 1998.

Supplementary Reading:

1. K. Ihokura and J. Watson, ***Stannic Oxide Gas Sensors***, CRC Press, 1994.
2. J. Fraden, ***Handbook of Modern Sensors Physics, Designs, and Applications, Springer***, 2004

CR 435	FUNCTIONAL MATERIALS AND DEVICES	3 credits [3-0-0]

Electrical and optical properties of materials. Dielectric, ferroelectric, super conductors and optical fibers. Magnetic properties: Microscopic origin of magnetism, domains, magnet fabrications and applications; Definition of smart materials: Introduction of ferroelectric materials, Ferri-electric, PTC Ceramics, Piezoelectric, Pyroelectric and Electro-Optic materials; Thin film processing and characterization. Application of ferro-electric materials; Introduction of shape memory alloys: Thermo-elastic martensitic transformations; shape memory alloys: Ni-Ti, Cu-Zn-Al, Ferromagnetic Shape Memory Alloy; Shape Memory Ceramics. Optical fibre technology, MEMS materials: Preparation and application.

Essential Reading:

1. K. Uchino, ***Ferroelectric Devices***, Marcel Dekker, 2000.
2. Z. L. Wang and Z. C. Kang, ***Functional and Smart Materials***, Springer 1998.

Supplementary Reading:

1. K. Otsuka and C. M. Wayman, ***Shape Memory Materials***, CambridgeUniversity Press, 1998.
2. N. Setter, ***Electroceramic-based MEMS: Fabrication Technology and Applications***, Springer, 2005.
3. J. W. Gardner, V. Varadan and O. O. Awadelkarim, ***Microsensors, MEMS, and Smart Devices***, John Wiley and Sons, 2001

CR 441	ELECTRICAL AND MAGNETIC CERAMICS	4 credits [3-1-0]

Elementary solid state science, electrical conduction, charge displacement process. Ceramic conductors: electrodes, ohmic resistors, varistors, thermistors, fuel cells and batteries, superconductors, materials system, powder synthesis, processing, properties, devices and application. Sensors: basic principles, classification, material system, powder synthesis, processing, devices and applications. Fast ion conductors, mixed ionic electronic conductors: material system, powder synthesis, processing, property and property modification by dopants. Dielectric and insulators, fundamentals of capacitors, classification of dielectric materials, materials system, powder synthesis, processing, properties, fabrication and application. Piezoelectric, pyroelectric and electro-optic fundamentals, materials system, synthesis, processing, properties, devices and application; Fundamentals of magnetism, magnetic ceramics basic concept, crystal structure of magnetic ceramics: spinel, hexa ferrite, garnet, structure modification by dopants, microstructure. Preparation of magnetic ceramics, different powder synthesis techniques, green body forming, sintering, permanent magnet technology, thin films. Magnetic properties of ceramics, origin of magnetic moment, magnetic order, domains and domain walls, soft ferrites, hard ferrites, magnetization dynamics, electrical and magneto-optical properties. Application and devices of ceramic magnet. Ferro-fluids, recent developments in this area.

Essential Reading:

1. R. C. Buchanan, ***Ceramic Materials for Electronics***, CRC Press, 2004.
2. D. C. Jiles, ***Introduction to Magnetism and Magnetic Materials***, CRC Press, 2nd Edition, 1998
3. J. Smit and H. P. J. Wijn, ***Ferrites***, Wiley, 1959.

Supplementary Reading:

1. L. M. Levinson, ***Electronic Ceramics: properties, device and applications***, CRC Press, 1987.
2. R. Valenzuela, ***Magnetic Ceramics***, CambridgeUniversity press, 1994.
3. A. Goldman, ***Modern Ferrite Technology***, Springer Science & Business, 2006.

CR 445	APPLICATIONOF PHASE DIAGRAMS	4 credits [3-1-0]

Some important three component systems- $CaO–Al_2O_3$ $–SiO_2$, $MgO-Al_2O_3-SiO_2$, $SiO_2-FeO-Fe_2O_3$, $MgO-FeO-Fe_2O_3$, $MgO-Al_2O_3-Cr_2O_3$. Quaternary System-$MgO-CaO-SiO_2-Fe_2O_3$, $MgO-SiO_2-CaO-B_2O_3$. The relevance of above phase diagrams in the ceramic system. Use of phase diagram in the sintering of ceramics; multiphase system containing a liquid phase, tungsten-carbide-cobalt system, porcelain, silicon nitride. Crystal growing techniques and use of phase diagrams in crystal growth; growth from stoichiometric melts, impurity distribution coefficient, constitutional supercooling and non-stoichiometric melts, single crystal growing of Yttrium-iron-garnet, cubic barium-titanate, gallium-phosphide, quartz crystal from hydrothermal solution; Phase diagrams in the development and use of refractories; Alumino-silicates, Silica and basic refractories, Fusion cast refractories. Liquid immiscibility in oxide systems. Study of dissolution of refractories in molten slag; Application of the phase diagrams in cement chemistry; calcium-alluminate cement and Portland cement

Phase diagrams in glass making, iron-carbon system, in the stabilization of zirconia phases. Phase diagrams in high pressure systems, recent developments in this area.

Essential Reading:

1. Y. M. Chiang, D. Birnie III and W. D. Kingery, ***Physical Ceramics: Principles for Ceramic Science and Engineering***, Wiley, 1996.
2. D. R. F. West, ***Ternary Phase Diagrams in Materials Science***, Maney Publishing; 3rd edition, 2002.
3. A. M. Alper (Editor), G. Kostorz (Series Editor), H. Herman (Series Editor), ***Phase Diagrams in Advanced Ceramics***, Treatise on Materials Science and Technology Academic Press. 1995.

Supplementary Reading:

1. A. M. Alper, ***Phase Diagrams: Materials Science and Technology, Vol. I, II and III***, Academic Press, 1970.
2. E. M. Levin, R. S. Roth, G. Smith, C. R. Robbins, H. F. McMurdie, L. P. Cook and M. K. Reser, ***Phase Diagram for Ceramists: salts***, The American Ceramic Society, 1975

CR 446	THIN FILM AND COATING	3 credits [3-0-0]

Film deposition techniques and processes: Introduction, Gas kinetics: vapours and gases, distribution function, transport properties. Vacuum technology: pump selection and exhaust handling, contamination sources and pressure measurement. Evaporation: thermodynamics of evaporation, sources, deposition monitoring. Deposition: adsorption, surface diffusion, nucleation, structure development, interfaces, adhesion, temperature control. Molecular beam epitaxy: process overview, deposition system, application, Sputter deposition, introduction, sputter sources, applications. Chemical Vapour deposition, Laser ablation, Plating: electroplating, electro-less plating, and application. Sol-gel coating, Pattern generation techniques: microlithography, optical tools for microlithography, etching, advanced process. Properties of Thin Film Materials: Substrates for thin film applications, thin film conductor materials, Resistors for thin film applications, thin film dielectrics, Thin film magnetics, advanced thin film materials. Characterization of Thin Film: Electro-Optical measurements, Chemical composition and Structural characterizations, nano-scale and atomic scale measurements. Thermal barrier coatings. Diamond films: nucleation and growth, properties of diamond, applications. Thin film optical materials: behavior of light at the interface, multilayer optical coating, preparation and formulation of optical thin films, applications, recent developments in this area.

Essential Reading:

1. K. Seshan, ***Hand Book of Thin Film Deposition Technique***, William Andrew INC, 2002
2. D. L. Smith, ***Thin film deposition***, McGraw-Hill Professional, 1995.

Supplementary Reading:

1. A. Elshabini-Riad and F. D. Barlow, ***Thin Film Technology Hand Book***, McGraw-Hill Professional, 1997**.**

CR 471	ADVANCED CERAMICS LABORATORY	2 credits [0-0-3]

Determination of bending strength in circular pellets; Determination of bending strength by three- and four-point bending methods; Determination of elastic modulus of bar type specimen; Determination of tensile strength of composites; Determination of fracture toughness by SENB and ISB method; Determination of hardness by Vickers Indentation; Determination of Curie temperature for ferro-electric materials; Temperature dependent conductivity of insulators/ semiconductors; Determination of frequency dependent dielectric constant and loss-factor of capacitors; Study of grain and grain boundary resistivity by Cole-Cole plot; Determination of B-H curve, permeability and magnetic loss of ferrite; Arrhenius plot for determination of activation energy of conduction.

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

DETAILED SYLLABI OF COURSES

CS 102	Data Structures and Algorithms	3-1-0	4
CS 171	Computing Laboratory – I	0-0-3	2
CS 172	Computing Laboratory – II	0-0-3	2
CS 211	Discrete Mathematics	3-1-0	4
CS 212	Object Oriented Programming and Web Application using C#	3-0-0	3
CS 213	Principles of Programming Languages	3-1-0	4
CS 222	Database Management Systems	3-0-0	3
CS 241	Analog Electronics	3-0-0	3
CS 242	Computer Organization and Architecture	3-1-0	4
CS 243	Digital Electronics	3-0-0	3
CS 270	Analog Electronics Laboratory	0-0-3	2
CS 271	Data Structure Laboratory	0-0-3	2
CS 272	Database Laboratory	0-0-3	2
CS 273	Digital Electronics Laboratory	0-0-3	2
CS 274	VHDL Programming Laboratory	0-0-3	2
CS 312	Systems Analysis and Design	3-0-0	3
CS 314	Simulation and Modeling	3-0-0	3
CS 315	Optimization Techniques	3-1-0	4
CS 321	Data Communication	3-0-0	3
CS 325	Cryptographic Foundations	3-0-0	3
CS 326	Data Communication and Computer Networks	3-0-0	3
CS 327	Relational Database Management Systems	3-0-0	3
CS 331	Theory of Computation	3-1-0	4
CS 332	Algorithm Analysis and Design	3-1-0	4
CS 333	Operating Systems	3-0-0	3
CS 334	Operating Systems Design	3-0-0	3
CS 335	Computer Graphics and Multimedia	3-0-0	3
CS 336	Digital Signal Processing	3-1-0	4
CS 338	Systems Software	3-1-0	4
CS 341	Microprocessors and Microcontrollers	3-1-0	4
CS 343	Digital Logic Design	3-0-0	3
CS 371	Data Communication Laboratory	0-0-3	2
CS 372	Systems Analysis and Design Laboratory	0-0-3	2
CS 373	Microprocessor Laboratory	0-0-3	2
CS 374	Operating Systems Laboratory	0-0-3	2
CS 375	Computer Graphics Laboratory	0-0-3	2
CS 376	Digital Signal Processing Laboratory	0-0-3	2
CS 377	Computational Statistics Laboratory	0-0-3	2
CS 378	Systems Programming Laboratory	0-0-3	2
CS 379	Network Design and Simulation Laboratory	0-0-3	2

CS 382	System Programming Laboratory	0-0-3	2
CS 384	Algorithm Analysis and Design Laboratory	0-0-3	2
CS 412	Software Engineering	3-1-0	4
CS 413	Advanced Programming Skills	3-0-0	3
CS 414	Software Project, Process and Quality Management	3-1-0	4
CS 416	Bioinformatics	3-1-0	4
CS 417	Graph Theory and Network Algorithms	3-0-0	3
CS 418	Real Time Systems	3-1-0	4
CS 421	Computer Networks	3-0-0	3
CS 423	Ad-hoc and Wireless Networks	3-1-0	4
CS 425	Data MiningandData Warehousing	3-1-0	4
CS 427	Network Security	3-1-0	4
CS 430	Information Theory and Coding	3-1-0	4
CS 431	Compiler Design	3-0-0	3
CS 432	Distributed Operating Systems	3-1-0	4
CS 433	Algorithm Design	3-0-0	3
CS 434	Image Processing	3-0-0	3
CS 435	Artificial Intelligence	3-0-0	3
CS 436	Soft Computing Techniques	3-0-0	3
CS 437	Soft Computing	3-0-0	3
CS 438	Pattern Recognition	3-1-0	4
CS 439	Computer Vision	3-0-0	3
CS 440	Cryptographic Foundation	3-0-0	3
CS 441	Advanced Computer Architecture	3-1-0	4
CS 442	Computer System Architecture	3-0-0	3
CS 443	Embedded Systems	3-1-0	4
CS 444	Cluster and Grid Computing	3-1-0	4
CS 445	Parallel Algorithms	3-1-0	4
CS 446	Graph Theory	3-0-0	3
CS 448	Artificial Intelligence & Neural Network	3-0-0	3
CS 449	VLSI System Design	3-1-0	4
CS 450	Multimedia & Computer Vision	3-0-0	3
CS 451	Image Processing	3-0-0	3
CS 471	Network Laboratory	0-0-3	2
CS 472	Software Engineering Laboratory	0-0-3	2
CS 473	Real Time Systems Laboratory	0-0-3	2
CS 474	Image Processing Laboratory	0-0-3	2
CS 477	Soft Computing Laboratory	0-0-3	2
CS 478	Parallel Computing Laboratory	0-0-3	2
CS 479	Advanced Linux Programming Laboratory	0-0-3	2
CS 481	Compiler Design Laboratory	0-0-3	2

CS 482	Distributed Computing Laboratory	0-0-3	2
CS 485	Artificial Intelligence Laboratory	0-0-3	2
CS 489	Computer Vision Laboratory	0-0-3	2

For B. Tech Courses (3 or 4 level) please refer to the B. Tech Curriculum and Syllabi, for M. Tech Courses (6 level) please refer to M. Tech Curriculum and Syllabi.

CS 102 data structures and ALGORITHMS 4 credits [3-1-0]

Prerequisites: NIL

Introduction**:** Data types, Abstract data types, data Structures, storage structure, Concept of 'O' notation, Time complexity & Space complexity issues. Arrays, Stacks & recursions, Queues, Linked list, Hashing, Trees Graphs & their ApplicationsLinked representation of Graph, Adjacency Matrix, Adjacency list, Shortest path algorithm, Graph Traversal: BFS, DFS, BDD and its application, Sorting Techniques **:** Bubble sort, Quick sort, selection sort, Heap sort, insertion sort, merge sort, radix sort & efficiency considerations. Searching Techniques**:** Sequential search, index sequential search, Binary search, Interpolation Search, Tree Searching, and Fibonacci Search. Files: properties of physical storage media, file organization techniques.

Essential Reading:

1. Tremblay & Sorenson, ***Introduction to Data Structures with applications***, Tata-McGraw-Hill, 2nd Ed., 2006.
2. M. A. Weiss, ***Data Structures and Algorithm Analysis in C***, Addison-Wesley, 3nd Ed., 2006.

Supplementary Reading:

1. S. Sahani, ***Data Structures, Algorithms and Applications in C++,*** Silicon Press, 2004.
2. A. V. Aho, J. E. Hopcroft & J. D. Ullman, ***Data Structures and Algorithms***, Addition-Wesley, 1998.
3. G. A. V. Pai, ***Data Structures and Algorithms: Concepts, Techniques and Applications***, Tata McGraw Hill, 1st Ed, 2008.
4. D. Samanta, ***Data Structures,*** PHI, 2004.

CS 171 COMPUTING LABORATORY – i 2 credits [0-0-3]

Prerequisites: NIL

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.

Essential Reading:

1. B. Gottfried, ***Programming with C***, 2nd Edition, Shaums Outline, TMH.
2. E. Balguruswami, ***Programming with C***, Tata McGraw Hill, 3rd Ed, 2006.

CS 172 COMPUTING LABORATORY – iI 2 credits [0-0-3]

Prerequisites: NIL

Implementation of: Classes and objects.; Constructors and Destructors.; Friend and virtual functions.; Operator overloading, function overloading.; Conversion of one data type to another.; Inheritance (single, hierarchical, multiple and multilevel).; Templates.; Exception handling.

Essential Reading:

1. E. Balguruswami, ***Programming with C++***, Tata McGraw Hill, 3rded, 2006
2. B. Strouptrup, ***C++ Programming Language***, Pearson Education, 3rd Ed, 2009.

CS 211 discrete MATHEMATICS 4 credits [3-1-0]

Prerequisites: NIL

Sets and Propositions: Mathematical induction, The Principle of Inclusion and Exclusion, Proposition, Theory of inference, Predicate Calculus, Methods of proof, Permutations and Combinations, Relations and Functions: properties of binary relations, Closure of relations, Warshall's algorithm, Equivalence relations Partial ordering relations and lattices, Chains and antichains, Functions, Composition of Functions, Invertible Functions, Recursive Functions, Pigeonhole principle, Graphs: representation of Graphs, operations on graphs, paths and circuits, graph traversals, shortest path in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, Traveling sales persons problem, Planar graphs, Graph Coloring, Application of Graphs, Tress and Cut-Sets: Rooted trees, Binary search trees, Spanning trees, Minimum spanning trees, Kruskal's Algorithm, Prims Algorithm, Transport Network, Modelling Computation: Languages, Phase structure and grammars, Types of grammars and Languages, Finite state machines, Discrete Numeric functions and Generating Functions, Recurrence relations and recursive algorithms, Linear recurrence relations, Solving Recurrence Relations by Generating Functions, Divide and conquer algorithms, Groups and rings: groups and subgroups, Cosets and Lagrange's theorem, Codes and Group codes, Boolean Algebras: Lattices and algebraic systems, Principle of duality, Distributive and complemented lattices, Boolean functions and Boolean expressions, Simplification of logic expressions using Karnaugh Map, Simplification of logic expressions using Quine-McClusky method, Propositional Calculus, Design and Implementation of Digital Networks, Switching Circuits.

Essential Reading:

1. C. L. Liu, D. P. Mohapatra, ***Elements of Discrete Mathematics: A computer Oriented Approach***, Tata-McGraw Hill, 3rd Ed, 2008.
2. B. Kolman and R. C. Busby, ***Discrete Mathematical Structures for Computer Science***, Prentice Hall of India, 5th Ed, 2002.

Supplementary Reading:

1. Kenneth H. Rosen, ***Discrete Mathematics and its Applications***, Tata McGraw Hill, 5thed, 2003.
2. J. P. Tremblay and R. Manohar, ***Discrete Mathematical Structures with Applications***, to Computer Science, TataMc-Graw Hill, 2001.
3. Joe L. Mott, A. Kandel, and T. P. Baker, ***Discrete Mathematics for Computer Scientists & Mathematics***, Prentice Hall of India, 2nded, 2006.
4. N. Deo, ***Graph Theory with applications to Engineering & Computer Science***, Prentice Hall of India, 2006.
5. S. Lipschutz, ***Discrete Mathematics***, Tata McGraw Hill, 2005.

CS 212 OBJECT-ORIENTED PROGRAMMING AND WEB APPLICATION USING C# 3 credits [3-0-0]

Object Oriented Programming (OOP): Introduction to object-oriented programming, concepts of classes, objects, encapsulation, inheritance, polymorphism, Data Abstraction etc; Introduction to C#, understanding C# in . NET environment; programming using C#.; Web Based Applications; Web-based projects, development process, role of web server, document object model, COM, . NET framework, HTML, DHTML, XML, CSS for designing web pages, life cycle of ASP pages, concepts of ASP. NET, components & characteristics, building ASP. NET web pages using C#, web configuration, data access using ADO. Net, XML etc; Database connectivity with SQL Server, Understanding DDL, DML, DCL, TCL commands, real time cases in database management, Security issues, maintenance and updating web projects etc.; Real Life Problem solving using OOP concepts; Requirements Analysis and Specification, Software Design; Real life software module development using C# and ASP. NET, Software Testing & Implementation; Multiple case studies to be undertaken.

Essential Reading:

1. Kogent Solution Inc, ***Black Book (Asp. Net & C#) 3. 5***, platinum edition, Dreamtech press, 2010.
2. E Balgurusamy, ***Programming in C#***, 2nd edition, Tata McGraw Hill, 2008.
3. Matthew MacDonald, ***Beginning ASP. NET 3. 5 in C#***, 2nd edition, Apress, 2010.
4. James A. Senn, ***System Analysis Design***, PHI.

Supplementary Reading:

1. Online and Offline Access to MSDN Library

CS 213 PRINCIPLES OF PROGRAMMING LANGUAGES 4 credits [3-1-0]

Prerequisites: CS 171 & CS 172

The Role of Programming Languages: Toward Higher-level Languages, Problems of Scale, Programming Paradigms, Language Implementation Bridging the Gap Language Description: - Syntactic Structure: Expression Notations, Abstract Syntax Trees, Lexical Syntax, Context -Free Grammars, Grammars for Expressions, Variants of Grammars; Statements: Structured Programming, Types: Data Representation, Procedure Activations; Object Oriented Programming: Groupings of Data and Operations: - Constructs fro Program Structuring, Information Hiding, Program Design with Modules, Modules and Defined Types, Class Declarations in C++, Dynamic Allocation I C++, Templates: Parameterized Types, Implementation of Objects in C++. 7. Object-Oriented Programming: - What is an Object?, Object-Oriented Thinking, Inheritance, Object-Oriented Programming in C++, An extended C++ example, Derived Classes and information Hiding, Objects in Smalltalk, Smalltalk Objects have self; Functional programming: Elements of Functional Programming, functional Programming in a Typed Languages, functions as First-Class Values, ML, Functional Programming with Lists

Other Paradigms: Logic Programming, an Introduction to Concurrent Programming.

Essential Reading:

1. R. Sethi, Programming Languages – Concepts & Constructs, 2nd Ed, Pearson Education.

Supplementary Reading:

1. R. W. Sebesta, ***Concepts of Programming Languages***, 8th edition, Addison-Wesley, 2007.
2. M. L. Scott, ***Programming Language Pragmatics***, 2nd edition, Morgan Kaufmann, 2005.
3. T. W. Pratt & M. V. Zelkowitz, ***Programming Languages: Design and Implementation***, 4th edition, Prentice-Hall, 2001.
4. S. Krishnamurthi, ***Programming Languages: Application and Intepretation***, Creative Commons Attribution-Non Commercial-Share Alike 3. 0, Version: http***: //www. cs. brown. edu/~sk/Publications/Books/ProgLangs/2007-04-26***

CS 222	database management systemS	3 credits [3-0-0]

Prerequisites: CS 102

Introduction to Database systems: Data Independence, Data Models, levels of abstraction, structure of DBMS, Relational Model, Integrity constraints, Relational Languages, Query Languages: SQL, QUEL, QBE, Aggregate operators, Embedded and Dynamic SQL. File Organization: Storage, Buffer management, Record and page formats, File organization techniques, Indexing. Query optimization: Query processing on various operations, Translating SQL queries, estimating the cost. Database design: E-R Model, Functional dependencies, normalization, multi-valued dependencies. Concurrency control and recovery: transaction, schedules, Lock based concurrency, Lock management, Concurrency control without locking, Crash recovery- log, check pointing, media recoveries. Database Security, Distributed databases design, Object Oriented database design & its implementation, Introduction to recent advances in database technology.

Essential Reading:

1. J. D. Ullman, ***Principles of Data Base Systems, Galgotia***, 2nded, 2003.
2. A. Silberschatz, H. F. Korth & A. Sudarshan, ***Database system Concepts***, McGraw Hill, 5thed, 2006.

Supplementary Reading:

1. B. Desai, ***An Introduction to database system***, Galgotia, 1997.
2. C. J. Date: ***An Introduction to Data Base Systems***, Addison Wesley, 1995.
3. R. Elmasri, S. Navathe, S. B. Navathe, R. Sunderraman, ***Fundamentals of Database Systems***, Addison Wesley, 2nded, 1994
4. R. R. Krishnan, ***Database Management Systems***, McGraw Hill, reprint 2007

CS 241	ANALOG ELECTRONICS	3 credits [3-0-0]

Prerequisites: NIL

Bipolar Junction Transistors and Field Effect Transistors, Biasing for BJT/FET and thermal stabilisation, transistors at low frequencies, small signal equivalent circuits, linear analysis. Feedback Amplifier Classifications, input and output resistance of feedback amplifiers, Effect of feedback on gain and impedance, frequency response of feedback amplifiers; emitter and source follower; low frequency response, h-parameters; transistors at high frequencies, high frequency equivalent circuit and response, gain-BW product. Crystal, Wien bridge and tuned oscillators, Multi stage amplifiers, Distortion in amplifiers. OP-amp bias currents and offset voltages, frequency response, measurement of OP-amp parameters, coupled amplifier, Class A and Class B power amplifiers; push –pull amplifiers; distortion in Class AB push-pull amplifiers; audio power amplifier, Class C amplifiers.

Essential Reading:

1. Malvino & D. J. Bates, ***Electronics Principles***, Tata McGraw Hill, 7th Ed, 2007.
2. J. Millman, C. C. Halkias, ***Integrated Electronics: Analog and Digital Circuits and Systems***, Tata McGraw Hill, 35th reprint, 2004.

Supplementary Reading:

1. Boylested & Nashelsky, ***Electronic Devices and Circuit Theory,*** Prentice Hall of India, 7th Ed, 2007.
2. D. A. Bell, ***Electronic Devices and Circuits***, Prentice Hall of India, 4th Ed, 2004.
3. J. Millman, ***Microelectronics***, McGraw Hill, 2nd Ed, 1988.

CS 242	Computer Organization and Architecture	4 credits [3-1-0]

Prerequisites: NIL

Overview of Computer Architecture and Organization: Contrast between computer architecture and organization; Fundamentals of computer architecture: Organization of von Neumann machine; Instruction format; execution cycle; Instruction types and addressing modes; Computer Arithmetic: representation of integers and real numbers; algorithm for carrying out common integer and floating-point operation; Memory system organization and architecture: Memory system hierarchy; main memory organization; cache memory; virtual memory; Interfacing and Communication: I/O fundamentals; I/O techniques; Interrupt; memory system design and Interfacing; Buses; Device subsystem: External storage system; RAID architecture; Control Unit Design: Instruction sequencing, Instruction interpretation, control memory, Hardwired Control, Micro programmed Control, Micro programmed Computers. I/O organization: Bus control, Serial I/O (study of Asynchronous and synchronous modes, USART & VART), Parallel Data transfer: (Program controlled: Asynchronous, synchronous & Interrupt driven modes, DMA mode, interrupt controller and DMA controller). Organization of CPU: Single vs multiple data path; ISA; Control unit; Instruction pipelining; Trends in computer architecture: CISC, RISC, VLIW, Introduction to ILP; Pipeline Hazards: Structural, data and control; Reducing the effects of hazards.

Essential Reading:

1. V. C. Hamacher, Z. G. Veranesic, and S. G. Zaky, ***Computer Organisation***, Tata McGraw Hill, 5th Ed, 2002.
2. J. P. Hayes, ***Computer Architecture and Organisation***, McGraw Hill, 3rd Ed, 1998.

Supplementary Reading:

1. M. M. Mano, ***Computer System Architecture***, Pearson, 3rd Ed, 2004.
2. W. Stallings, ***Computer Organization and Architecture – Designing for Performance***, Prentice Hall of India, 7th Ed, 2007.
3. D. A. Pattersen and J. L. Hennesy, ***Computer Organisation and Design: The HardwareSoftware Interface***, Elsevier, 2nd Ed, 2006

CS 243	DIGITAL ELECTRONICS	3 credits [3-0-0]

QuineMcCluakey method of Minimization, Minimization of multiple I/O Switching functions, Design of combinational logic: few examples. Full Adder / Subtracter, BCD Adder, LAC Adder, Decoder, MUX / DEMUX three structure, Combinational logic design using ROM array, Applications of MSI designs. Difference between Combinational and Sequential circuits, Flip Flops, Counters, Shift Registers and PLA. Basic models of sequential M/C, Analysis of Asynchronous and synchronous circuits, Synthesis of completely and incompletely specified synchronous sequential M/Cs. Fault detection and location, classical methods, path senistizing method, Equivalent Normal-Form method, Two-level-circuit, fault detection, Multi-level-circuit, fault detection, Boolean difference method.

Essential Reading:

1. M. Mano and M. D. Cilette, ***Digital Design,*** Pearson education, 4th Ed. 2008.
2. R. P. Jain, ***Modern Digital Electronics***, Tata McGraw Hill, 3rd Ed, 2007.

Supplementary Reading:

1. J. F. Wakerly, ***Digital Design Principles and practices***, PHI, 4th Ed, 2005.
2. M. Mano, ***Digital Logic and Computer Design***, 1st Ed, Pearson, 2002.

CS 270	ANALOG ELECTRONICS LABORATORY	2 credits [0-0-3]

Design of 2 stage RC coupled amplifier.; Design of integrator and differentiator using OP-AMPS.; Design and verification of different amplifier configurations with OPAMPS.; Determination of different electrical parameters of OPAMP.; Design of OPAMP application circuits using P-SPICE simulator.

CS 271	DATA STRUCTURE LABORATORY	2 credits [0-0-3]

Prerequisites: CS 102

Following is a list of experiments to be coded in C or C++. Details of each experiment are to be provided by the subject teacher.; Understanding the use of arrays.; Programming insertion, deletion, merging in arrays. Realization of various linked lists.; Simulating a stack.; Using stack for various conversions of expression like prefix etc.; Realizing a queue.; Performing various operations on queue.; Simulate a tree and perform various tree traversals.; Programming various sorting algorithms.; Understanding the use of hashing.

CS 272	DATABASE LABORATORY	2 credits [0-0-3]

Prerequisites: CS 102

Database Lab:

Study of SQL syntax; Study of Oracle syntax; Study of DB2 syntax; Writing Views, Assertions, Triggers; PL/SQL Programs to be simulated given by instructor; Generating forms and reports; Following database to be designed and queries to be processed using SQL.; Oracle and DB2: Order processing; insurance; student enrollment; library; banking enterprise; Primary keys, data types and relevant queries for the above database will be supplied by the instructor; Front end may be created by using VB, Java.

CS 273	DIGITAL ELECTRONICS LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

To study and verify various logic gates.; Verification of DE-MORGAN' theorem.; Implementation of Boolean function using NAND and NOR logic.; Implementation of half and full adder circuit is using NAND logic gate.; To design and study RS and JK Flip-flop.

To study and design JK flip-flop.; To design module-7 counter.; Designing a buffer register 4 bit using D-flip flop.; Design a 2 to 4 line decoder using AND and NOT gates.; Design a decimal to binary priority encoder

CS 274	VHDL PROGRAMMING LABORATORY	2 credits [0-0-3]

Prerequisites: CS 243

Write VHDL code to implement the following: Full adder using multiplexer; Binary Multiplexer (8 bit/16 bit); Floating-Point addition; Carry save Multiplier (8 bit); Two's complement Multiplier; Parity Encoder; GCD Processor; Universal Shift register with asynchronous reset; FSM to detect the flag sequence of HDLC frame

CS 312	SYSTEMS ANALYSIS AND DESIGN	3 credits [3-0-0]

Prerequisites: NIL

Concepts of data and information, System Concepts, Components of a system, Characteristics of a system, Types of systems: closed systems, open systems, man made systems. Information Systems, Types of information Systems: Transaction processing systems, Management information systems, Decision support systems, Expert systems. Computer based information systems (CBIS), Feasibility study. Systems development life cycle model, Iterative waterfall model, Prototype model, Incremental model, Spiral model. Systems Analysis and Design, Classical and Structured approaches, Structured Analysis tools: DFD, Data dictionary, Decision tree etc., Systems Design, input/ output design, Software Design and Documentation tools: HIPO and Warnier / Orr Diagrams. System testing and quality assurance. SystemImplementation. HW/SW selection, Conversion, Software Maintenance. Activitynetwork. CPM, PERT, Gnatt Chart, Recent trend in systems analysis and design.

Essential Reading:

1. H. George, Valacich, ***Modern Systems Analysis and Design***, Pearson, 2nd Ed, 2005.
2. J. A. Senn, ***Analysis and Design of Information Systems***, McGraw Hill, 1989.

Supplementary Reading:

1. H. C. Lucas, ***The Analysis, Design and Implementation of Information Systems***, McGraw Hill, 1985.
2. E. M. Awad, ***System Analysis & Design***, Galgotia Publication, 2002.
3. R. Mall, ***Fundamentals of Software Engineering***, Prentice Hall of India, 2nd Ed, 2006.

CS 314	SIMULATION AND MODELING	3 credits [3-0-0]

Prerequisites: NIL

Definition of System: Types of Systems-continuous and discrete; Modeling process and Definition of a model; Computer workload and preparation of its model; verification and validation modeling procedures; Comparing model data with real system data; Differential and partial differential equation models; Combining discrete events and continuous models; (Examples of a computer should be used for illustration and discussion purposes). Simulation Process: Use of simulation; Discrete and continuous simulation languages (such as GPSS, SLAM, SIMSCRIPT, II and SIMULA); Study and use of one language (depending on the availability) in detail. Use of Database and A. I. techniques in the area modeling and simulation.

Essential Reading:

1. J. Banks, ***Modeling and Performance Measurement of Computer Systems***, Prentice Hall of India, reprint 2007.
2. A. M. Law, W. D. Kelton, ***Simulation Modelling and Analysis***, Tata McGraw Hill, 2000.

Supplementary Reading:

1. T. A. Payer, ***Introduction to Simulation***, McGraw-Hill.
2. J. Reitmen, ***Computer Simulation Application***, Wiley, reprint 2000.
3. W. A. Speriet, ***Computer – aided Modeling and Simulation***, Academic Press, reprint 2002.

CS 315	Optimization techniques	4 credits [3-1-0]

Prerequisites: MA 101, MA 102, MA 201, MA 202

Origin, Characteristics and Techniques, operations research Modeling, Linear Programming Constraints with less than equal to, equal to and greater than equal to types. The Simplex method, Dual simplex method, Revised simplex method, Duality theory and sensitivity analysis. Transportation and Assignment problems, Traveling Salesman problem using branch and bound method, Network analysis including PERT-CPM, Integer programming, Non-linear programming problem solving using Fibonnacci search method, Golden ratio method, Gradient search method, Gradient projection method and Hessian matrix method, Queuing theory and applications for different M/M/I and M/M/C models. Inventory models considering holding cost, ordering cost and penalty costs.

Essential Reading:

1. H. A. Taha, ***Operations Research an Introduction***, Prentice Hall of India, 8^{th} Ed, 2007.
2. F. S. Hillier, G. J. Lieberman, ***Introduction to Operation Research***, 8^{th} Edition, Mc-Graw-Hill, 2008.

Supplementary Reading:

1. S. S. Rao, ***Optimisation Theory and applications***, Wiley Eastern Ltd. India, 1978, reprint 2005.
2. B. E. Gillet, ***Introduction to Operation Research: a computer oriented algorithmic approach*** Tata McGraw Hill, 1979, reprint 2005.

CS 321	data COMMUNICATION	3 credits [3-0-0]

Prerequisites: NIL

Data transmission fundamentals: historical overview; time/frequency representation of data signals; elements of a communications link; definition of key terms; factors affecting system design, Binary and multi-level signaling: information transfer rate; calculation of channel capacity; bandwidth efficiency, Baseband data transmission: the problem of inter symbol interference; achieving a Nyquist channel response; recovery of symbols from noise; bit error rate performance for baseband data systems, Bandpass digital modulation: binary modulation schemes (eg ASK, FSK, PSK); multi-level digital modulation (e.g. M-ary ASK, M-ary FSK, M-ary PSK, QAM), Coding theory and practice: source coding; channel coding; block coding; convolutional coding; combined coding and modulation, Multi-user digital modulation techniques such as frequency division multiple access (FDMA); time division multiple access (TDMA); code division multiple access (CDMA); combined multiple access systems; Error detection and correction, Digital transmission fundamental

Essential Reading:

1. B. Forouzan, ***Data Communications and Networking***, Tata McGraw Hill, 4^{th} Ed, 2007.
2. W. Stallings, ***Data and Computer Communications***, Prentice Hall of India, 8^{th} Ed. 2007.

Supplementary Reading:

1. Leon-Garcia & I Widjaja, ***Communication Networks, Fundamental Concepts & Key Architecture***, Tata McGraw Hill, 2^{nd} Ed, 2003.

CS 325	CRYPTOGRAPHIC FOUNDATIONS	3 credits [3-0-0]

Prerequisites: CS 211, CS 332.

Introduction to cryptography**:** Attacks, Services, and Mechanisms, Security Attacks, Security Services, A Model for Internet work Security. Conventional Encryption: Classical and Modern Techniques, Conventional Encryption: AlgorithmsTriple DES, International Data Encryption Algorithm, Blowfish, RC5, CAST, RC2, Characteristics of Advanced Symmetric Block Ciphers. Confidentiality Using Conventional Encryption**:** Placement of Encryption Function, Traffic Confidentiality, Key Distribution, Random Number Generation.; Public-Key CryptographyPrinciples of Public-Key

Cryptosystems, The RSA Algorithm, Key Management, Diffie-Hellman Key Exchange, Elliptic Curve Cryptography, Message Authentication and Hash Functions: Authentication Requirements, Authentication Functions, Message Authentication Codes, Hash Functions, Security of Hash Functions and MACs. Hash and Mac Algorithms (MD5 Message Digest Algorithm, Secure Hash Algorithm (SHA-l), RIPEMD, HMAC), Digital Signatures and Authentication Protocols and Web Security.

Essential Reading:

1. W. Stalling, ***Cryptography and Network Security: Principles and Practices***, 4th Ed, 2005
2. B. A. Forouzan, ***Cryptography and Network Security,*** McGraw Hill, 2nd Ed, 2004.

Supplementary Reading:

1. J. Hershey, ***Cryptography Demystified***, McGraw Hill, 2003
2. R E Smith, ***Internet Cryptography***, Addison Wesley
3. J. Knudsen, ***Java Cryptography***, O'Reilly, 1998.

CS 326 DATA COMMUNICATION AND COMPUTER NETWORK 3 credits [3-0-0]

Prerequisites: NIL

Data transmission fundamentals: time/frequency representation of data signals; elements of a communications link; definition of key terms; Binary and multi-level signaling: information transfer rate; calculation of channel capacity; bandwidth efficiency, Baseband data transmission: the problem of inter symbol interference; achieving a Nyquist channel response; recovery of symbols from noise; bit error rate performance for baseband data systems, Advantages of Computer networks, LAN vs. WAN, ISO/ISI seven-layer architecture, networks topologies. Physical Layer: transmission media, analog transmission, digital transmission. Data Link Layer: Framing, Error detection and correction, MAC Layer : Ethernet Network Layer : Routing Algorithms – Shortest path, distance vector, link state routing, flooding, hierarchical routing, Internetworking – Tunneling, Encapsulation, Fragmentation, Virtual circuits, datagrams, Internet Protocol (IP) – Header Structure, addresses, options, etc. Routing protocols (examples: RIP, HELLO, OSPF, BGP). Classless Inter-Domain Routing, ICMP, ARP, RARP, BOOTP, DHCP. Transport Layer : Flow and error control, multiplexing, establishing and releasing a connection. Transmission Control Protocol, User Datagram Protocol, Domain Name Service.

Essential Reading:

1. B. A. Forouzan, ***Data Communication and Networking***, Tata McGraw Hill, 4th Ed, 2007.
2. A. S. Tanenbaum, ***Computer Networks***, Prentice Hall of India, 4th Ed, 2006.

Supplementary Reading:

1. F. Halsall, ***Data Communication, Computer Networks and Open Systems***, 4th Ed, AddisonWelsey, 2003.
2. B. A. Forouzan, ***TCP/IP Protocol Suit***, Tata McGraw Hill, 3rd Ed, 2006.

CS 327 RELATIONAL DATABASE MANAGEMENT SYSTEMS 3 credits [3-0-0]

Prerequisites: NIL

Introduction to Database Systems: Goals of Data Base Management Systems, Data Independence, Data Models, Brief Review of file system, File systems vs. DBMS, Relational Languages, Structure of DBMS, Storage structures of files. Database design: ER model, Relational model and relational algebra, Relational database design, Queries in a DBMS, Basic queries in SQL, Database design issues, Functional dependencies, Normal forms. Introduction to Database security; Introduction to Object Oriented database design.

Essential Reading:

1. J. D. Ullman, ***Principles of Data Base Systems, Galgotia Publisher***, New Delhi, 2003.
2. Silberschatz, H. F. Korth & A. Sudarshan, ***Database system Concepts***, McGraw Hill, 5th Ed, 2006.

Supplementary Reading:

1. B. Desai, ***An Introduction to database system***, Galgotia, 1997.
2. C. J. Date: ***An introduction to Data Base Systems***, Addison Wesley, 1995.
3. R. Elmasri, S. Navathe, S. B. Navathe & R. Sunderraman, ***Fundamentals of Database Systems***, Addison Wesley, 2nd Ed, 1994
4. Raghu Ram Krishnan, ***Database Management Systems***, McGraw Hill, reprint 2007.

CS 331	Theory of Computation	4 credits [3-1-0]

Prerequisites: CS 211

Finite Automata and Regular Expressions**:** Deterministic and non-deterministic finite automata, regular expressions, Two way finite automata, finite automata with output**:** Mealy and Moore machines; Properties of Regular Sets**:** Pumping lemma, closure properties, decision algorithm, MyHill- Nerode theorem and minimization of finite automata; Context-Free Grammars(CFG): CFGs, derivation trees, simplification, Chomsky normal forms, Greibach normal forms; Pushdown Automata(PDA): Definitions, relationship between PDA and context free languages; Properties of Context-Free Languages**:** Pumping lemma, closure properties, decision algorithm; Turing Machines**:** The turing machine model, computable languages and functions, techniques for turing machine construction, modification of turing machines, church's hypothesis, Turing machines as enumerators; Undecidability: properties of recursive and recursively enumerable languages, universal Turing machines, rice's theorem, post correspondence problem, greibach's theorem, introduction to recursive function theory, oracle computation; Chomsky Hierarchy**:** regular grammars, unrestricted grammars, context sensitive languages, relations between classes of languages.

Essential Reading:

1. Mishra & Chandrasekharan, ***Theory of computer science: Automata language andcomputation***, Prentice Hall of India, 3rd Ed, 2007.
2. P. Linz, ***Introduction to Formal Language and Computation***, Narosa, 2nd Ed, 2006.

Supplementary Reading:

1. Nasir & Sirmani, ***A Text Book on Automata Theory***, Cambridge University Press, 2008.
2. H. R. Lewis & C. H. Papadimitriou, ***Elements of the Theory of Computation***, Prentice Hall of India, 2nd Ed, 2006.

CS 332	ALGORITHM ANALYSIS and DESIGN	4 credits [3-1-0]

Prerequisites: CS102, MA 101, MA 102

Abstract data structure as an organization of data with specified properties and operations Time and space analysis of algorithms Asymptotic Notation: Big Oh, Omega, Theta Notations, Average, best and worst case analysis Simple recurrence relations and use in algorithm analysis Analysis of Algorithms: Loops, Recursive Calls (Selection Sort, Insertion Sort, Euclid's Algorithm, Hanoi Towers), Solving Recurrences.; Algorithmic strategies: Categorizing algorithms by methodology, Brute-force/exhaustive search algorithms, Greedy Algorithms, Divide and Conquer Strategy, Dynamic Programming, Backtracking algorithm and Branch-Bound Algorithm.; String Search problem: Naïve algorithm, Rabin-Karp scheme, FSA-based algorithm Knuth-Morris-Pratt algorithm; Complexity theory: Decidability of problems: Halting problem, NP-class of problems, P-class problems, NP=P question, Polynomial problem reduction, Boolean satisfiability and Cook's theorem, NP-hardness and NP-completeness, NP-completeness FAQ including how to handle NP-hard problems, Examples of NP-completeness proofs: SAT to 3-SAT, 3-SAT to 3-D Matching, Reasoning with Cardinal algebra, Other models of computation: Art. Neural Net, Quantum Computing, DNA computing. Concept of lower bound theory & approximation algorithm.

Essential Reading:

1. E. Horowitz, S. Sahni and S. Rajasekaran, ***Fundamentals of Computer Algorithms,*** University Press, Indian reprint, 2009.
2. T. Cormen, C. Leiserson, and R. Rivest and C. Stain, ***Introduction to Algorithms*** Prentice Hall of India, 3rd Ed, 2006.

Supplementary Reading:

1. P. H. Dave and H. B. Dave, ***Design and Analysis of Algorithm***, Pearson Ed 2008.
2. S. K. Basu, ***Design Methods and Analysis of Algorithms***, Prentice Hall of India, 1st Ed, 2005.

CS 333	OPERATING SYSTEMS	3 credits [3-0-0]

Prerequisites: NIL

Evolution of Operating Systems and Overview, Basic Concepts: Batch processing, Multiprogramming, Interrupts, Hardware concepts, Different types of OS, Goals, OS Structure, System calls. Process Management: Process, Concurrent Processes, Threads, Multithreading, Scheduling Algorithms, Inter-process Communication: Critical Section problem, Synchronization Mechanisms: software and hardware, semaphores, monitors, message passing, Classical IPC problems, Deadlocks: conditions, Deadlock Handling Strategies. Memory Management: Fixed & Variable, Paging, Segmentation, Virtual Memory: Demand paging, page replacement algorithms, Trashing, Strategies to control Trashing. File & Device Management: Files, Directory, File system Implementation, Example File systems, I/O hardware, I/O buffering, RAID. Security & Protection: Breaches, Solutions, mechanisms, Inside Attacks, outside attacks. Case study on UNIX.

Essential Reading:

1. J. L. Peterson & A. Silberschatz, ***Operating System Concepts***, John Wiley & Sons, 7th Ed, 2008.
2. A. S. Tanenbum***, Modern Operating Systems***, Pearson, 3rd Ed, 2008.

Supplementary Reading:

1. Harris, ***Schaum's Outline of Operating Systems***, Tata McGraw Hill, 11th Reprint, 2006
2. Stallings, ***Operating Systems, Internals and Design Principles***, 5th Ed, PHI, 4th print, 2008
3. M. J. Bach, the ***Design of the UNIX operating system***, Prentice Hall, reprint 2006.

CS 334	Operating Systems DESIGN	3 credits [3-0-0]

Prerequisites: CS 171/CS 172

Evolution of Operating Systems and Overview, Basic Concepts: Batch processing, Multiprogramming, Interrupts, Hardware concepts, Different types of OS, Goals, OS Structure, System calls. Process Management: Process, Concurrent Processes, Threads, Multithreading, Scheduling Algorithms, Queuing Models (M/M/1, M/M/K), Inter-process Communication: Critical Section problem, Synchronization Mechanisms: software and hardware, semaphores, monitors, message passing, Classical IPC problems, Deadlocks: conditions, Deadlock Handling Strategies. Memory Management: Fixed & Variable, Paging, Segmentation, Virtual Memory: Demand paging, page replacement algorithms, Trashing, Strategies to control Trashing. File & Device Management: Files, Directory, File system Implementation, Example File systems, I/O hardware, I/O buffering, RAID. Security & Protection: Breaches, Solutions, mechanisms, Inside Attacks, outside attacks. Concepts of Advanced OS: Distributed, Real Time, Multimedia, Multiprocessor, Network, Embedded, Database Operating Systems. Case studies – DOS, UNIX and Windows 2000. Basic OS Design Principles: Goals, Interface Design, Performance Considerations, Trends in Design.

Essential Readings:

1. J. L. Peterson & A. Silberschatz, ***Operating System Concepts***, John Wiley & Sons, 7th Ed, 2008.
2. A. S. Tanenbum***, Modern Operating Systems***, Pearson, 3rd Ed, 2008.

Supplementary Readings:

1. Harris, ***Schaum's Outline of Operating Systems***, Tata McGraw Hill, 11th Reprint, 2006.
2. Crowley, ***Operating system, a Design-Oriented Approach***, Tata McGraw Hill, 2006.
3. M. J. Bach, The ***Design of the UNIX operating system***, Prentice Hall, reprint 2006.
4. Stallings, Operating Systems, Internals and Design Principles, 5th Ed, PHI, 4th print, 2008.

CS 335	computer graphics and Multimedia	3 credits [3-0-0]

Prerequisites: MA 101, MA 102

Introduction to Computer Graphics: Use of computer graphics, Elements of picture creation; Graphics Hardware: Display technologies, Graphics display devices, Graphics input primitives and devices; Two dimensional output primitives: Different forms of line equations, Points, Lines, Line drawing algorithms, Circle generating algorithms, Ellipse generating algorithm, Parallel algorithms, Filled area primitives; Two dimensional transformations: The geometries of transformations, Linear transformations, Translation, Rotation in plane, Rotation in space, Reflection, Homogeneous coordinates, Composite transformations; Polygons; Two dimensional viewing: Window to view port transformations, Line clipping, Polygon clipping; Three dimensional concepts: Display methods, Transformation, three dimensional viewing, Projections; Three dimensional shapes representations: Spline, Bezier curves and surfaces, Octrees, BSP trees, Fractal geometry; Halfspaces; Visible surface detection; Solid modeling; Shading; Advanced modeling techniques; Animation; Multimedia; Multimedia authoring tools; Graphics and image data representation; Color in Image & Video; Basics of Video and Audio; Compression; Content based retrieval.

Essential Reading:

1. D. Hearn and M. P. Baker, ***Computer Graphics, C Version***, Pearson, 2nd Ed, 2003.
2. Ze-Nian Li, M. S. Drew, ***Fundamentals of Multimedia,*** Pearson, 1st Ed, 2004.

Supplementary Reading:

1. F. S. Hill, ***Computer Graphics using Open GL***, Pearson, 2nd Ed, 2001.
2. R. Steinmetz, K. Nahrstedt, ***Multimedia Systems***, Springer, 2004.
3. J. D. Foley, A. Van Dam, S. K. Feiner and J. F. Hughes, ***Computer Graphics - Principles and Practice***, Second Edition in C, Addison Wesley, 2nd Ed, 2003.
4. D. F. Rogers, J. A. Adams, ***Mathematical Elements for Computer Graphics,*** McGraw Hill, 2nd Ed, 2001

CS 336	dIGITAL SIGNAL PROCESSING	4 credits [3-1-0]

Prerequisites: CS 241, MA 101, MA 102

The DFT and Digital Convolution: The DFT and its relationship to other transforms, properties of the DFT, FFT, DIT and DIF FFT algorithms, prime factor FFT algorithms, Analysis and Design of discrete-time systems in the frequency domains, Frequency domain characteristics of LTI systems, LTI frequency selective filters, linear filtering method based on DFT, the Goertzel algorithm and chirp Z-transform algorithm. Inverse systems and Deconvolutions, Realisation of discrete systems: Design of digital filters, Quantization effects in Digital Signal Process, Power Spectrum Estimation, Adaptive Filters.

Essential Reading:

1. J. G. Proakis and D. G. Manolkis, ***Digital Signal Processing: Principles, Algorithms and Applications***, Prentice Hall of India, 3rd Ed, 1996, reprint 2005.

Supplementary Reading:

1. V. Oppenheim & R. W. Schafer, ***Digital Signal Processing***, Prentice Hall of India, 8th Ed, 2002.
2. S. W. Smith, Digital Signal Processing: A Practical Guide for Engineers and Scientists, Newness – Elsevier Science, 1sted, 2002.

CS 338	SystemS SOFTWARE	4 credits [3-1-0]

Prerequisites: CS 341, CS 334

System Software and Machine Architecture, IBM 360 Instruction Set Architecture and Assembly language programs, The simplified Instructional Computer, traditional (CISC) Machine, RISC Machines; Language Processing; Assemblers, Cross assemblers, Macro processor, Single pass and multi pass, Linkers, Loaders, Relocating loaders and direct linking loaders, Compilers and Interpreters, Cross compilers, Lexical analyzer, Syntax analyzer, Intermediate and Machine code generation, Implementation Examples; Formal grammars and languages, Software Toolsfor program Development, Editors, Debug Monitors, Programming Environments, user Interface. Introduction to Operating Systems.

Essential Reading:

1. B. B. Brey, ***The Microprocessor 8086/8088, 80186/188, 80286, 80386, 80486 and Pentium and Pentium Pro Processors, Pentium 2, Pentium 3 and Pentium 4: Architecture, Programming and Interface***, Prentice Hall of India, 7th Ed, 2007.
2. M. A. Mazidi, JG Mazidi and RD Mckinlay, ***The 8051 Microcontroller and Embedded System***, Prentice Hall of India, 2nd Ed, 2006.

Supplementary Reading:

1. Liu & Gibson, ***Microcomputer System – The 8086/8088 Family Architecture, Programming and Design***, Prentice Hall of India, 2nd Ed, 2006

CS 341	MICROPROCESSORS AND MICROCONTROLLERS	4 credits [3-1-0]

Prerequisites: CS 243

Architecture of the 8086/8088 microprocessor, Internal operations, Maximum mode, Minimum mode of operation, Addressing modes, Instruction Format, Instruction execution timing, 8088 vs 8086; Assembly Language Programming: Data Transfer instruction, Arithmetic and Logical instructions, String Manipulation instructions etc needed for ALP, Modular programming: Simple assembler directives and operators, Linking and relocation, Stack, Procedures, Interrupt, Macro, Programming examples. Byte and string manipulation, I/O programming. 8087 Numeric data processor and its use in the 8086/8088 system, 8089 I/O processor (IOP), Architecture, Communication between CPU & IOP. Arithmetic Coprocessor, MMX and SIMD Technology; Bus interface, The 80386/80486/Pentium/Pentium II/Pentium III/Pentium IV Microprocessors; 8051 Microcontroller: Architecture, Instruction, Programming and Interfacing.

Essential Reading:

1. B. B. Brey, ***The Intel Microprocessors 8086/8088, 80186/188, 80286, 80386, 80486 and Pentium and Pentium Pro Processors, Pentium 2,, Pentium 3 and Pentium 4: Architecture, Programmingand Interface***, Prentice Hall of India, 7thed, 2007.
2. M. A. Mazidi, J. G. Mazidi and R. D. McKinlay, The 8051 Microcontroller and Embedded Systems, Prentice Hall of India, 2nd Ed, 2006

Supplementary Reading:

1. Liu & Gibson, ***Microcomputer Systems - The 8086/8088 Family Architecture***, ***Programming and Design***, Prentice Hall of India, 2nd Ed, 2006.
2. D. V. Hall, ***Microprocessor and Interfacing***, Tata McGraw Hill, 2nd Ed, 2006.

CS 343	DIGITAL LOGIC DESIGN	3 credits [3-0-0]

Prerequisites: NIL

History and overview, logic circuits, switching, memory, registers, digital systems, Boolean logic, sequential logic, gates, circuits, combinational circuits, Switching theory, number systems, binary arithmetic, switching algebra, minimization of switching functions, design of medium scale combinational logic module, multiplexers, demultiplexers, encoders, decoders, comparators, multipliers, dividers, ALUs, Hierarchical design, Memory elements: clocked and unclocked memory devices, master-slave devices, basic flip flops, timing constraints and propagation delays, data registers, RAM, Sequential logic : FSM, Mealy and Moore models, Synchronous sequential circuits, functional units, Digital System Design: Hierarchical, Modular, synthesis, design principles and techniques, functional units, controlling concepts, timing concepts, PLDs, FPGA, PLA, ROM, PAL, PLD. Modeling and simulation: schematic capture, schematic modeling, hardware description languages (VHDL, verilog), Functional simulation, simulation test bench design.

Essential Reading:

1. S. Brown and Z. Vranesic, ***Fundamentals of Digital Logic with VHDL Design***, Tata McGraw Hill, 2005
2. A. B. Marcovitz, ***Introduction to Logic Design***, Tata McGraw Hill, 2nd Ed, 2005.

Supplementary Reading:

1. R. P. Jain, ***Modern Digital Electronics***, Tata McGraw Hill, 3rd ed, 2003.
2. S. C. Lee, ***Digital Circuits & Logic Design***, Prentice Hall of India, 2001.

CS 371	DATA COMMUNICATION LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Study of serial and parallel communication; Study of modem communication; Study of wireless communication; Principles of time division multiplexing; Voice communication; Principles of pulse code modulation techniques; Bit synchronization and frame synchronization; Principles of data reconditioning; Amplitude shift keying modulation and demodulation techniques; Delta modulation and demodulation.

CS 372	SYSTEMS ANALYSIS AND DESIGN LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

For Questions 1 – 10, do the followings:

Prepare the SRS document. You have to identify the appropriate requirements for each problem.; Draw the Context flow diagrams, level 1 and level 2 DFDs, using any CASE tool.

Draw the Structure charts, using any CASE tool.; Develop the corresponding software using C with a user friendly GUI and appropriate Database.; Develop a Library Information System for a technological University.; Develop a software for student registration in a technological University.; Develop a software for hall management of your Institute.; Develop a software for the Guesthouse automation of your Institute.; Develop a software for automating various bookkeeping activities of the student's cooperative store of your Institute.; Develop the Student's Academic Record Management Software of your Institute.; Develop a word processing software with some limited number of facilities such as making bold, italics, underline, cut, copy and paste etc.; Develop a graphics editor software package, using which one can create / modify several common types of graphics entities.; Develop a software for automating the various activities associated with developing a CASE tool for structured software analysis.; Develop software for automating various activities of the department offices of your Institute.

CS 373	MICROPROCESSOR LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Design of a variable time delay counter (mod 8).; Measuring pulse width of a square wave.; Interfacing a stepper motor.; Interfacing a matrix keyboard (4×4).; Interfacing traffic light controller.; Implementing ADC.; Generating triangular saw tooth and square wave.; Communication between microprocessors using 8255PPI chip.; Generate various waveforms using DAC; Interfacing CRT to microprocessor.; Programming using 8086 kit.

CS 374	OPERATING SYSTEMS LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Process related assignments: A parent process creates a child process that prints its PID.; The child creates a grandchild and sleeps 120 seconds.; The grandchild immediately exists.; The parent sleeps for 60 seconds and then kills all the processes.; message passing between child process and parent process using message queue; message passing through pipes and shared memory; Simulation of CPU Scheduling Algorithms. (FCFS, RR, SJF, SPN, SRTF, HRRN, Priority, Multilevel Queuing); Simulation of Dekker's, Petersons, Bakery Algorithms; Program to test the creation of 15-message queue starting at id-number 0-14.; Program to solve classical DINNING PHILOSPHER PROBLEM; Simulation of Banker's Algorithm for Deadlock Avoidance, Prevention; Simulation MVT and MFT with best fit, first fit, next fit and worst fit algorithms.; Program for FIFO, LRU, and OPTIMAL page replacement algorithm?; Simulate the following file organization techniques; (a) Single Level Directory; (b) Two Level Directory; (c) Hierarchical (d) DAG; Basic Shell Script problems provided by Instructor on various shells of Unix

CS 375	COMPUTER GRAPHICS LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Basic shapes rasterisation.; Scan conversion of polygons; Polygon, Pattern filling; Understanding 2D transformation; Realizing various Projections; Representing curves and surfaces; Realizing parametric cubic curves and bicubic surfaces; Visible Surfaces Determination; Realizaition of illumination and shading; Basics of OpenGL

Thematically oriented project for the whole duration of the course for individual students or group of students

CS 376	DIGITAL SIGNAL PROCESSING LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Representation of digital signal; Waveform generation; Convolution and Deconvolution; Correlation, Cross Correlation; Signal Transformation; Filter Design; Filter requirements and specification; Zero-Pole Analysis; Spectral Analysis; Case studies in DSP

CS 377	COMPUTATIONAL STATISTICS LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Data Structure: Vector and matrix data manipulation. Data input/output. Data format. **Statistical graphics:** scatter plots, histograms, quantile-quantile (QQ) plot. visualizing bivariate data.; **Random numbers:** probability integral transform, how to generate random variables, vectors, matrices and stochastic processes.; **Matrix algebra:** Singular value decomposition, Cholesky factorization, Generalized inverse (Psudo inverse). least-squares estimation.; **Monte-Carlo methods:** Monte-Carlo integral, importance sampling, Monte-Carlo inference.; **Markov Chains**: random walks, transition probability. Chapman-Kolmogorov equation. invariant distributions.; **Markov chain montecarlo** (MCMC): Metropolis-Hastings algorithms. Gibbs sampler. Bayesian inference. Bayes estimates.; **Bootstrap methods:** Bootstraping techniques are introduced for estimation and inference problems.

Essential Reading:

1. Wendy L. Martinez and Angel R. Martinez, ***Computational Statistics Handbook with MATLAB*** Chapman & Hall/CRC, 2002

CS 378	SYSTEMS PROGRAMMING LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Review of Instruction Set Architecture (8085, 8051 & IBM 360); Fixed Point Arithmatic, Text Processing, Keyboard and Screen Processing, Disk processing, Copy-Protection Schemes, Implementation of a simple editor, adding syntax directed facilities to an editor; Implementation of Assembler; Single Pass; Two-pass; Multi-pass; implementation of Macro Processor; Single Pass; Integration with Assembler; Implementation of Loaders and Linkers; Implementation of Compiler; Lexical analyzer (Lex); Parser (Yacc); Intermediate code generation; Machine Code Generation

CS 379	NETWORK DESIGN AND SIMULATION LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Installation and configuration of NS2; Creating a network: nodes, links and queues; Creating connections, traffic and computing routers; Insertion of errors and analysis of trace file; Simple project on NS2 – wired, wireless and combination of wired and wireless; Implementation of new protocols in NS2.

CS 382	SYSTEM PROGRAMMING LABORATORY	2 credits [0-0-3]

Review of Instruction Set Architecture (8085, 8051 & IBM 360); Fixed Point Arithmetic, Text Processing, Keyboard and Screen Processing, Disk processing, Copy-Protection Schemes, Implementation of a simple editor, adding syntax directed facilities to an editor; Implementation of Assembler: SinglePass; Two-pass; Multi-pass; Implementation of Macro Processor; SinglePass; Integration with Assembler; Implementation of Loaders and Linkers; Implementation of Compiler; Lexical analyzer (Lex); Parser (Yacc); Intermediate code generation; Machine Code Generation

CS 384	ALGORITHM ANALYSIS AND DESIGN LABORATORY	2 credits [0-0-3]

Prerequisites: NIL

Programming that uses recurrence relations to analyze recursive algorithms. Computing best, average, and worst case time complexity of various sorting techniques. Solving an optimization problem (TSP or 0-1 knap sack, or n-queen problem etc.) using different algorithmic strategies: Brute-force algorithms, Greedy algorithms, Divide-and-conquer, Backtracking, Branch-and-bound, Heuristics, Randomized algorithms, Dynamic programming. Performance analysis of different internal and external sorting algorithms with different type of data set. Use of divide and conquer technique to solve some problem that uses two different algorithm for solving small problem. Implementation of different basic computing algorithms like Hash tables, including collision-avoidance strategies, Search trees (AVL and B-trees), Representations of graphs (adjacency list, adjacency matrix), Depth- and breadth-first traversals, Shortest-path algorithms (Dijkstra's and Floyd's algorithms), Transitive closure (Floyd's algorithm), Minimum spanning tree (Prim's, Solin's and Kruskal's algorithms), Topological sort, Pattern matching and string/text algorithms. Performance analysis of algorithms related to network Flow and matching problems Verification of lower bound of an algorithm, analyzing the performance of randomized algorithms for a specific problem; The laboratory work involves implementing various types of algorithms in C++, C (through the creation of header file) and Perl programming.

CS 412	SOFTWARE ENGINEERING	4 credits [3-1-0]

Prerequisites: CS312

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, Analysis concepts and principles, Analysis Modeling, Design Concepts and principles, Architectural design, User Interface Design, Component level Design, Software Testing Techniques, Software testing Strategies, Technical metrics for software. Object oriented software engineering Object Oriented Concepts and principles, Object oriented analysis, object oriented Design, Object oriented testing, Technical metrics for object-oriented Systems**.**

Essential Reading:

1. R. S. Pressman, ***Software Engineering A Practitioner's Approach***, Tata McGraw Hill, 6^{th} Ed, 2005.
2. I. Sommerville, ***Software Engineering***, Pearson, 7^{th} Ed, 2005.

Supplementary Reading:

1. P. Jalote, ***An Integrated Approach to Software Engineering***, Narosa, 2^{nd} Ed, 1999.
2. A. Behferooz & F. J. Hudson, ***Software Engineering Fundamentals***, Oxford Univ. Press, 1996.
3. R. Mall, ***Fundamentals of Software Engineering***, Prentice Hall of India, 2^{nd} Ed, 2006.

CS 413	ADVANCED PROGRAMMING SKILLS	4 credits [3-1-0]

Prerequisites: NIL

Different programming paradigms, Introduction to Java, Data types, Variables, Arrays, Operators, Control statements, Classes, Constructors, Destructors, Garbage collection, Overloading methods, Overloading Constructors, Argument passing, Returning objects, Recursion, Inheritance, Method overriding, Dynamic method dispatch, Abstract classes, Packages, Importing packages, Interfaces, Nested interfaces, Applying interfaces, Handling Exceptions, Java built-in exceptions, Introduction to multi-threaded programming, The java thread model, Synchronization, Messaging, The thread class and runnable interface, Creating a thread, Creating multiple threads, Enumertions, I/O basics, Applets, The HTML applets tag, Java library, Handling events, Introduction to AWT, The concurrency utilities, Java beans, Introduction to swings, Servelets. Introduction to C#, Basic concepts of . NET: the C# environment, Literals, Variables and data types, Operators and expressions, Control statements, Methods in C#, Arrays, Strings, Structures and Enumertions, Classes and objects, Inheritance and polymorphism, Interfaces, Operator overloading, I/O basics, Handling Exceptions, multi-threading in C#, Windows and web based application development on . NET, Recent trends in programming methodologies.

Essential Reading:

1. H. Schildt, ***The Complete Reference Java***, Tata Mc-Graw Hill, 7^{th} Ed, 2006.
2. E. Balagurusamy, ***Programming in C#: A Primer***, Mc-Graw Hill, 2^{nd} Ed, 2008.

Supplementary Reading:

1. E. Balagurusamy, ***Programming in JAVA***, Mc-Graw Hill, 3^{rd} Ed, 2007.
2. J. M. Slack, ***Programming and Problem Solving with JAVA***, Thomson/Brooks Core Publishing Company, 1^{st} Indian Reprint, 2007.

CS 414	SOFTWARE PROJECT, PROCESS AND QUALITY MANAGEMENT	4 credits [3-1-0]

Prerequisites: CS 312, CS 412

Introduction to S/W project management, S/W project management competencies, responsibilities of a software project manager, Software process, S/W process models, project planning, organization of project team, S/W size estimation, estimation of effort & duration, Halstead's software Science, models, dependency & scheduling, staffing, Organizing a software engineering project, S/W configuration management, monitoring & controlling S/W projects, developing requirements, risk management, project tracking & control, communication & negotiating, S/W quality, S/W quality engineering, defining quality requirements, quality standards, practices & conventions, ISO 9000, ISO 9001, S/W quality matrices, managerial and organization issues, defect prevention, reviews & audits, SEI capability maturity model, PSP, six sigma

Essential Reading:

1. B. Hughes, M. Cotterell, ***Software Project Management***, McGraw Hill, 4^{th} Ed, 2005.
2. R. Walker, ***Software Project Management***, Pearson, 2003.

Supplementary Reading:

1. R. H. Thayer, ***Software Engineering Project management***, IEEE CS Press, 2^{nd} Ed, 1988.
2. R. Pressman, ***Software Engineering A Practitioner's approach***, McGraw Hill, 4^{th} Ed, 2005.

CS 416	bioinformatics	4 credits [3-1-0]

Pre-requisite: CS 332, CS 425

Genetics

Cell and Molecular Biology

Biochemistry

Introduction; Databases - mapping, sequence, structure, non-redundant; Sequence alignment - pair wise and multiple; phylogenetics; Structure prediction methods - homology, threading, abinitio; Sequence analysis - class and secondary structure prediction; motifs - PROSITE; detecting functional sites in DNA; OR Finder; Computer science perspective - pattern recognition, hidden Markov models; Data Miming Using Soft computing Techniques.

Essential Reading:

1. A. D. Baxevanis & B. F. F. Ouellette, ***Bioinformatics***, Wiley Interscience, 1998.
2. A. M. Lesk, ***Introduction to bioinformatics***, OXFORD University Press, 1^{st} Ed, 2003.

Supplementary Reading:

1. S. L. Salzberg, D. B. Searls and S. Kasifeds, ***Computational methods in molecular biology***, Elsevier, 1998.
2. R. F. Doolittle, ***Computer methods for macromolecular sequence analysis***, Academic Press, 1996.
3. M. Bishop, ***Guide to human genome computing***, Academic Press.

CS 417	GRAPH THEORY AND NETWORK ALGORITHMS	3 credits [3-0-0]

Prerequisite : CS326

Introduction: Graphs, Isomorphism, Walks, Paths, Circuits, Trees, Properties of Trees, Cotrees and Fundamental Circuits, Cut Sets, Fundamental Cut Sets and Cut Vertices, Planar and Dual Graphs, Metric Representation of Graphs, Coloring and covering and partitioning of a graph, chromatic number, chromatic partitioning, chromatic polynomials, matching, covering, four color problem, Directed graphs, some type of directed graphs, Directed paths, and connectedness, Euler digraphs, trees with directed edges, fundamental circuits in digraph, matrices A, B and C of digraphs adjacency matrix of a digraph,, enumeration, types of enumeration, counting of labeled and unlabeled trees, polya's theorem, graph enumeration with polya's theorem.

Graph Algorithms: Elementary Graph Algorithms, Representations of graphs, Breadth-first search, Depth-first search, Topological sort, strongly connected components

Minimum Spanning Trees: Growing a minimum spanning tree, The algorithms of Kruskal and Prim, **Single-Source Shortest Paths:** Shortest paths and relaxation, Dijkstra's algorithm, The Bellman-Ford algorithm, Single-source shortest paths in directed acyclic graphs, Difference constraints and shortest paths, **All-Pairs Shortest Paths:** Shortest paths and matrix multiplication, The Floyd-Warshall algorithm, Johnson's algorithm for sparse graphs, and A general framework for solving path problems in directed graphs; **Maximum Flow:** Flow networks, The Ford-Fulkerson method, Maximum bipartite matching, Preflow-push algorithms, The lift-to-front algorithm

Essential Reading:

1. Thomas H. Cormen, Charles E. Leiserson and Ronald L. Rivest, ***Introduction to Algorithms***, Prentice Hall of India, 3rded, 2006.
2. N. Deo, ***Graph Theory with Applications to Engineering and Computer Science***, Prentice Hall of India, 2004.

Supplementary Reading:

1. Douglas B. West, ***Introduction to Graph Theory***, 2nded, Prentice Hall of India, 2007.
2. R. Diestel, ***Advanced Graph Theory***, Springer Verlag Heidelberg, New York, 2005
3. M. T. Goodrich and R. Tamassia, ***Algorithm Design: Foundations, Analysis, and Internet Examples***, Wiley, 1sted, 2001.

CS 418	REAL TIME SYSTEMS	4 credits [3-1-0]

Prerequisites: CS334, CS341

Introduction to Real-Time systems, applications of Real-Time systems, basic model of Real-Time systems, characteristics of Real-Time systems, types of Real-Time systems: hard, firm, soft, timing constraints, modeling timing constraints, Real-Time task scheduling: basic concepts, clock driven scheduling, table driven scheduling, cyclic, schedulers, hybrid schedulers, event driven scheduling, EDF Scheduling, RMA, DMA, resource sharing among RT tasks, Priority inversion, Priority Inheritance Protocol, Highest Locker Protocol, Priority Ceiling Protocol, Scheduling Real-Time tasks in multiprocessor and distributed systems, Fault-tolerant scheduling of tasks, clocks in distributed Real-Time systems, Commercial Real-Time Operating Systems, timers, UNIX and Windows as RT OS, POSIX, PSOS, VRTX, QNX, RT Linux, Lynx, other RT OS, benchmarking RT OS, RT communications, QoSframework, models, Real-Time Communication in a LAN, IEEE 802. 4, RETHER, Communication over Packet Switched Networks, Routing algorithms, RSVP, rate control, RT databases, Applications, characteristics of temporal data, Concurrency control, Commercial RT databases.

Essential Reading:

1. P. A. Laplante, ***Real-Time Systems Design & Analysis***, Willey, 3rd Ed, 2004.
2. R. Mall, ***Real-Time Systems***, Pearson, 2007.

Supplementary Reading:

1. C. M. Krishna and K. G. Shin, ***Real-Time Systems***, McGraw Hill, reprinted 2004.
2. J. W. S. Liu, ***Real-time Systems,*** Pearson Education, 6th impression, 2008.

CS 421	ComPuter NETWORKs	3 credits [3-0-0]

Prerequisites: CS 326

Network fundamentals: protocols and standards; reference models; the significance of layered network architectures; connections and connectionless protocols, Physical links and interfaces: modems and modem standards; LAN characteristics and concepts; interconnection of LANs; WAN characteristics and concepts, Link layer aspects, synchronous and asynchronous transmission; Framing, Error detection and correction, Sliding window protocols; MAC Layer; network layer aspects, addressing, connection vs connectionless, Routing Algorithms, internetworking; transport layer aspects, reliable transport connections, Internet Protocol (IP); naming and addressing; routing; the Transmission Control Protocol (TCP); application and management protocols, Exploring Internet services: the dial-in end-user; the direct connection user; the Internet Service Provider; the global Internet, Emerging technologies over the Internet, such as IPv6 and ATM for a multimedia network; Internet Telephone;

Essential Reading:

1. L. L. Peterson and B. S. Davie, ***Computer Networks – A System Approach***, Elsevier, 4th Edition, Reprint 2009.

2. A. S. Tanenbaum, ***Computer Networks***, Pearson, 4th Ed, 2008.

Supplementary Reading:

1. B. A. Forouzan, ***TCP/IP protocol suite***, Tata McGraw Hill, Reprint 2008
2. F. Halsall, Data Communication, Computer Networks and Open Systems, Addison Welsey, 4th Ed, 2003.

CS 423	Ad-hoc and WIRELESS NETWORKS	4 credits [3-1-0]

Prerequisites: CS 421

Ad Hoc Wireless Networks: Issues in Ad Hoc Wireless Networks, Ad Hoc Wireless Internet; MAC Protocols for Ad Hoc Wireless Networks: Issues in Designing a MAC Protocol for Ad Hoc Wireless Networks, Classifications of MAC Protocols; Routing Protocols for Ad Hoc Wireless Networks: Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Power-Aware Routing Protocols; Multi-cast routing in Ad Hoc Wireless Networks: Issues in Designing a Multicast Routing Protocol, Classifications of Multicast Routing Protocols, Energy-Efficient Multicasting, Multicasting with Quality of Service Guarantees, Application-Dependent Multicast Routing; Security Protocols for Ad Hoc Wireless Networks: Security in Ad Hoc Wireless Networks. Network Security Requirements. Issues and Challenges in Security Provisioning. Network Security Attacks. Key Management. Secure Routing in Ad Hoc Wireless Networks; Energy Management in Ad Hoc Wireless Networks: Classification of Energy Management Schemes, Transmission Power Management Schemes, System Power Management Schemes.

Essential Reading:

1. C. S. Ram Murthy, B. S. Manoj, ***Ad Hoc Wireless Networks: Architectures and Protocols***, Prentice Hall of India, 2nd Ed. 2005.
2. RaminHekmat, ***Ad-hoc Networks: Fundamental Properties and Network Topologies***, Springer, 1st Ed. 2006.

Supplementary Reading:

1. B. Tavli and W. Heinzelman, ***Mobile Ad Hoc Networks: Energy-Efficient Real-Time Data Communications***, Springer, 1st Ed. 2006.
2. G Anastasi, E Ancillotti, R Bernasconi, and E S Biagioni, ***Multi-Hop Ad Hoc Newtorks from Theory to Reality***, Nova Science Publishers, 2008

CS 425	DATA MINING AND DATA WAREHOUSING	4 credits [3-1-0]

Prerequisites: CS 222, MA 201

Introduction to Data mining: Motivation for Data Mining, its importance, Role Data in Data Mining, Data Mining functionalities, patterns in data mining, Type of patterns, Classification of Data Mining Systems, Major issues in Data Mining; Data Warehousing and OLTP technology for Data Mining, Data Mining Languages, and System Architectures, Concept Description: Characterization and Comparison, Mining Association Rules in Large Databases, Classification and Prediction, Cluster Analysis, Mining Complex Data, Applications and Trends in Data Mining Characteristics of data warehouse, Data Mart, Online Analytical Processing, OLAP tools, Data warehouse Architecture, Organizational Issuer, Tools for Data warehousing, Performance consideration, case studies.

Essential Reading:

1. J. Han & M. Kamber, ***Data Mining: Concepts and Techniques***, Morgan Kaufmann, 2nd Ed, 2006.
2. M. J. A. Berry and G. Linoff, ***Mastering Data Mining: The Art and Science of Customer Relationship Management***, Wiley Computer Publishing, 2000.

Supplementary Reading:

1. P. Adriaans & D. Zantinge, ***Data Mining***, Addison Wesley, 1996.
2. R. Mattison, ***Data Warehousing: Strategies, Tools and Techniques***, McGraw Hill, 1996.
3. P. Ponniah, ***Data Warehousing Fundamentals: A Comprehensive Guide for IT Professionals***, Wiley, 2001.

CS 427	NETWORK SECURITY	4 credits [3-1-0]

Prerequisites: CS 325

Key exchange protocols. Diffie-hellman and its variants, Man in the middle attack. PKI and certificate based key exchange. Key management. Protocol weakness in TCP/IP and other protocols. Various types of attacks. Security protocol at application level: PGP, SHTTP, SSH etc. Security protocol at socket level: SS/TSL. Security protocol at network level: IPSec. Security protocol for remote connections through dial-up etc: PPTP, L2TP. Firewall and packet filtering. Proxy or application level gateways as security devices. Virtual private networks, Intrusion detection system. Privacy protection and anonymity services. Electronic payment system.

Essential Reading:

1. W. Stalling, ***Cryptography and Network Security: Principles and Practices***, 4th Ed, PHI, 2007.
2. B. A. Forouzan, ***Cryptography and Network Security,*** McGraw Hill, 1st Ed.

Supplementary Reading:

1. J. M. Kizza, ***Computer Network Security***, Springer, 2005.
2. Peterson and Davie, ***Computer Networks A System Approach***, Elsevier, 3rd Ed.

CS 430	**INFORMATION THEORY AND CODING**	**4 credits [3-1-0]**

Prerequisites: MA 201

Introduction to information Theory, Information and entropy, properties of entropy of a binary memory less source, Measure of Information, Source Coding, Shannon-Fano coding, Huffman coding, Arithmetic Coding, Predictive Coding, Lempel Zivcoding, channel coding, Channel capacity, noisy channel coding theorem for DMC. Linear block codes, generator matrices, parity check matrices, encoder syndrome and error detection-minimum distance, error correction and error detection capabilities, cyclic codes, coding and decoding. Coding convolutional codes, encoder, generator matrix, transform domain representation state diagram, distance properties, maximum likelihood decoding, Viterbi decoding, sequential decoding, interleaved convolutional codes.

Essential Reading:

1. R. Bose, ***Information Theory Coding and Cryptography,*** Tata McGraw Hill, 2008.
2. Khalid Sayood, ***Introduction to Data Compression***, Elseiver, 2004.

Supplementary Reading:

1. S. Roman, ***Coding and Information Theory***, Springer, 1992.
2. R. J. McEliece, ***The Theory of Information and Coding***, Cambridge Uinv Press, 2004.
3. T. M. Cover, J. A. Thomas***, Elements of Information Theory***, Wiley, 2008
4. F. J. MacWilliams, N. J. A. Sloane, ***The Theory of Error Correcting Codes***, Elseiver, 1988.

CS 431	**COMPILER DESIGN**	**3 credits [3-0-0]**

Prerequisites: CS 331 & CS 338

Introduction: Introduction and overview of the compilation process, Model of a compiler, translators, interpreters, assemblers, languages, Types of compilers, assemblers, interpreters and compilers. Compilation of simple expressions and statements, Organization of a compiler, compiler design tools, bootstrapping, compiler, Computer architecture vs. compiler design; **Context-Free Grammar and Syntax Analysis:** Syntax analysis, Parsing: Top-Down and Bottom Up parsing, general parsing strategies. Brute-force approach, recursive descent parser and algorithms, simple LL(1) grammar, LL(1) with null and without null rules grammars, Bottom-up parsing- Handle of a right sentential form, Shift-reduce parsers, operator precedence parsing, LR, SLR, canonical LR and LALR grammar and parsers; **Symbol-Table contents, organization and Management; Syntax –Directed Definitions and Translations**: syntax-directed translation schemes, intermediates code generation, translation schemes for programming language constructs; **Code Optimization, Code Generation, Error Handling.**

Essential Reading:

1. A. V. Aho, Ravi Sethi & Jeffrey D. Ullman, ***Compilers: Principles, Techniques, and Tools***, Pearson Education, 1st Ed, 2008.
2. K. C. Louden, ***Compiler Construction Principles and Practice***, Thomson Learning Inc. 1st Ed, 2007.

Supplementary Reading:

1. A. W. Apple, ***Modern compiler implementation in C***, Cambridge University Press, 1st Ed, 2003.
2. W. A. Barrett, John D. Couch, C. Couch, C***ompiler Construction: Theory and Practice***, Science Research Associates, 1979.
3. K. C. Louden, ***Compiler Construction: Principle and practice***, Galgotia, 1997.

CS 432	**DISTRIBUTED OPERATING SYSTEMS**	**4 credits [3-1-0]**

Prerequisites: CS334, CS421

Introduction to parallel Computing, Solving problems in parallel, Structures of parallel computers, Instruction level parallel processing, Parallel Algorithms, Parallel programming, Operating Systems for parallel computers, Performance Evaluation of parallel computers; Characterization of distributed systems, Design goals, Communication and computer networks, Distributed processing, Distributed operating systems, Client Server Communications, Remote Procedure calls, File Service, Name Service, Distributed transactions and concurrency control, fault tolerance and security.

Synchronization & Coordination, Distributed Algorithms, research issues.

Essential Reading:

1. G. Coulororis, J. Dollimore & T. Kindberg, ***Distributed Systems: Concepts and Design***, Addison-Wesley, 3rd Ed, 2001.
2. M. Singhal & N. G. Shivaratri, ***Advanced Concepts in Operating Systems***, McGraw Hill, 1994.

Supplementary Reading:

1. P. K. Sinha, ***Distributed Operating Systems***, IEEE Press, 1997.
2. H. F. Jordan, ***Fundamentals of Parallel Processing***, Pearson, 2004
3. C. Hughes & T, Hughes, ***Parallel and Distributed Programming Using C++***, Pearson, 1st Ed, 2004.
4. W. Buchanan, ***Distributed Systems and Networks***, Tata McGraw Hill, 2004.
5. P. S. Pacheco, ***Parallel Programming with MPI***, Morgan Kaufmann, 1997.

CS 433	ALGORITHM DESIGN	3 credits [3-0-0]

Prerequisites: NIL

History and overview: Identifying some contribution to algorithms and relate their achievements to the knowledge area. Associate some of the themes involved with algorithms, Name some applications where algorithms are important, Describe how computer engineering users or benefits from algorithm; Basic algorithm analysis: Asymptotic analysis of upper bound and average complexity bounds, Identifying difference among average, best and worst case behaviors, Big 'O', little 'o' omega, and theta notation, Empirical measurement of performance, Time and space tradeoffs in algorithms, Using recurrence relations to analyze recursive algorithm. Problem, problem representation, solution space, solution through best algorithm, methods of algorithm design and analysis. The relationship of algorithms to data structures; Algorithmic strategies: Categorizing algorithms by methodology, Brute-force/ exhaustive search algorithms, Greedy Algorithms, Divide and Conquer Strategy, Dynamic Programming, Backtracking algorithm and Branch-Bound Algorithm; Computing Algorithms: Simple numerical algorithms, sequential and binary search algorithms, sorting algorithms, Hash Table, including collision avoidance strategies, Binary search Trees, Representation of Graphs, Depth and Breadth first traversal, shortest path algorithms(Dijkstra and Floyd's algorithm) Transitive closure (Floyd's algorithm), Minimum spanning tree(Prim's and Kruskal algorithm); Algorithmic complexity: Tractable and intractable problems, definition of the class P and NP, NP completeness (Cook's theorem), Standard Np-complete problems, Uncomputable functions, The halting problem, Implications of Uncomputability, Coping with intractability.

Essential Reading:

1. E. Horowitz, S. Sahni and S. Rajasekaran, ***Fundamentals of Computer Algorithms,*** University Press, Indian reprint, 2008.
2. T. Cormen, C. Leiserson, and R. Rivest and C. Stain, ***Introduction to Algorithms*** Prentice Hall of India, 3rd Ed, 2006.

Supplementary Reading:

1. M. Weiss, Data Structures and Algorithm Analysis in C++, Pearson, 4th Ed, 2008.
2. S. K. Basu, ***Design methods and Analysis of Algorithms***, Prentice Hall of India, 1st Ed, 2005.

CS 434	IMAGE PROCESSING	3 credits [3-0-0]

Prerequisites: NIL

Two-Dimensional Systems & Mathematical Preliminaries**:** Linear Systems and Shift Invariance; the Fourier Transform; Optical and Modulation Transfer Functions; Matrix Theory Results; Block Matrices and Kronecker Products; Random Signals; Discrete Random Fields; the Spectral Density Function; Some results from information theory. Image Perception, Image Sampling and Quantization, Image Transforms, Image Enhancement, Image Filtering and Restoration, Image Analysis and Computer Vision Spatial Feature Extraction; Transform Features; Edge Detection; Boundary extraction; Boundary, Region, Moment Representation; Structure; Shape Features; Texture; Scene Matching and Detection; Image Segmentation; Classification Techniques; Image Understanding. Image Reconstruction from Projections, Image Data Compression

Essential Reading:

1. R. C. Gonzalez & R. E. Woods, ***Digital Image Processing***, Prentice Hall, 3rd Ed, 2008.
2. A. K. Jain, ***Fundamentals of Digital Image Processing***, Prentice Hall of India, 1st Ed, 1989.

Supplementary Reading:

1. W. K. Pratt, ***Digital Image Processing,*** Wiley-Interscience, 4th Ed, 2007.
2. A. Rosenfled & A. C. Kak, Vol. I, ***Digital Picture Processing***, Academic Press, 1976.

3. J. S. Lion, ***Two Dimensional Signal and Image Processing***, Prentice Hall, 1st Ed, 1989.

CS 435 ARTIFICIAL INTELLIGENCE 3 credits [3-0-0]

Prerequisite : NIL

Basic concepts of AI; Problems in AI; Applications; Production systems; Problem solving methods; Forward vs backward reasoning; Search in state spaces, state-space graph, uninformed search, heuristic search, general graph search algorithms, 2-agent games; knowledge representation using predicate calculus; rules of inference; converting arbitrary wff to conjunction of clauses, resolution reputation system; Answer extraction; Intro to expert system.

Essential Reading:

1. E. Rich and K. Knight, ***Artificial Intelligence***, Tata McGraw Hill, 2nded, 1991.
2. N. J. Nilsson, ***Principles of Artificial Intelligence***, Narosa, 1986.

Supplementary Reading:

1. S. Russel and P. Norvig, ***Artificial Intelligence: a modern Approach***, Pearson, 2nded, 2003.
2. D. W. Patterson, ***Introduction to Artificial Intelligence and Expert Systems***, Prentice Hall of India, 2006.

CS 436 soft computing TECHNIQUES 3 credits [3-0-0]

Prerequisites: CS 211

Introduction to Neorofuzzy and Soft Computing, Fuzzy set theory, Fuzzy Rules, Fuzzy Reasoning, Fuzzy inference System, Neural Networks; Radial basis and recurrent neural networks, Hopfield Networks, Comparision of RBF and MLP Network, Running Algorithms, NeuroFuzzy Modeling, Applications of Soft Computing to Signal Processing, Image Processing, Forecasting, XOR Problem-traveling salesman problem, Image compression suing MLPs-character retrieval using hopfield networks, Introduction to Genetic Algorithm hybrid Systemsetc.

Essential Reading:

1. V. Kecman, Learning and Soft Computing, Pearson, 1st Ed, 2001.
2. D. E. Goldberg, ***Genetic Algorithms in Search Optimization and Machine Learning***, Addison Wesley, 3rd Ed.

Supplementary Reading:

1. B. Kosko, ***Neural Network and fuzzy systems***, Prentice Hall of India, 2006.
2. S. Goonatilake & S. Khebbal, ***Intelligent Hybrid Systems***, Wiley, 1995.

CS 437 soft computing 3 credits [3-0-0]

Prerequisite : NIL

Introduction to Neorofuzzy and Soft Computing, Fuzzy set theory, Fuzzy Rules, Fuzzy Reasoning, Fuzzy inference System, Neural Networks; Radial basis and recurrent neural networks, Hopfield Networks, Comparision of RBF and MLP Network, Running Algorithms, NeuroFuzzy Modeling, Applications of Soft Computing to Signal Processing, Image Processing, Forecasting, XOR Problem-traveling salesman problem, Image compression suing MLPs-character retrieval using hopfield networks, Introduction to Genetic Algorithm hybrid Systemsetc.

Essential Reading:

1. V. Kecman, Learning and Soft Computing, Pearson, 1sted, 2001.
2. D. E. Goldberg, ***Genetic Algorithms in Search Optimization and Machine Learning***, Addison Wesley, 3rded.

Supplementary Reading:

1. B. Kosko, ***Neural Network and fuzzy systems***, Prentice Hall of India, 2006.
2. S. Goonatilake & S. Khebbal, ***Intelligent Hybrid Systems***, Wiley, 1995.

CS 438 PATTERN RECOGNITION 4 credits [3-1-0]

Prerequisites: CS 102, MA 102, MA 201

Introduction to pattern recognition, statistical pattern recognition, decision trees, classification using decision trees, obtaining Prules from decision trees, missing attribute values, error rates on recall sets, pruning decision trees, obtaining Prules by evolution, Bayes classification, estimation of probabilities, nearest neighbor classification, performance issues of a nearest neighbor classifier, Neural classifier, training of neural classifier, clustering, Agglomerative hierarchical clustering, K-means clustering, syntactic pattern recognition.

Essential Reading:

1. R. Shighal, ***Pattern Recognition: Techniques and Applications***, Oxford University Press, 1st Ed, 2006.
2. Christopher M. Bishop, ***Neural Networks for Pattern Recognition,*** Oxford University Press, 1st Ed, 2003.

Supplementary Reading:

1. William Gibson, ***Pattern Recognition***, Berkley Press, 1st Ed, 2005.
2. Christopher M. Bishop, ***Pattern Recognition and Machine Learning,*** Springer, 1st Ed, 2007.

CS 439	COMPUTER VISION	3 credits [3-0-0]

Prerequisite : NIL

Image Formation and Image Models: Cameras; Radiometry – Measuring Light; Shadows and Shading; Color representation; Linear filters; Edge Detection; Pyramids and Textures; Multiple view geometry; Stereo; Optical flow; Affine structure from motion; Projective structure from motion; Calibration; Segmentation; Fitting; Linear Tracking; Non-Linear Tracking; Template Matching; Object Recognition; Case study of various applications.

Essential Reading:

1. D. A. Forsyth, J. Ponce, ***Computer Vision – A Modern Approach***, Pearson, 2005.
2. Linda. G. Shapiro, George C. Stockman, ***Computer Vision***, Prentice Hall, 2001.

Supplementary Reading:

1. Bernd Jähne, Horst Haußecker, ***Computer Vision and Applications – A Guide for Students and Practitioners,*** Academic Press, 2000.
2. R. J. Schalkoff, ***Digital Image Processing and Computer-Vision***, John Wiley and Sons, 1989.

CS 441	advanced computer architecture	4 credits [3-1-0]

Prerequisites: CS 242, CS 341

Metrics for computer performance: clock rate, MIPS, CPI; Strength and weakness of performance metrics; role of Amdalh's in computer performance; Classification of computer architecture: SIMD, MIMD, SISD and MISD; Processing unit design: Data path implementation, Microprogrammed execution. Instruction pipelining and parallel processing, Instruction level parallelism: VLIW, Vector processor, Multithreaded processor, Superscalar architecture; branch prediction; Prefetching; Speculative execution; Principles of pipelining and vector processing: Pipelining, Instruction and Arithmetic Pipelines, Principles of Designing Pipelined Processor, Vector Processing Requirements. Structure and Algorithms for array processors: SIMD Array Processors, SIMD Interconnection Networks, Parallel Algorithms for array Processors, Associative Array Processing. Multiprocessor architecture and programming: Inter-processor Communication Mechanisms, System Deadlocks and Protection, Multiprocessor Scheduling Strategies, Parallel Algorithm for Multiprocessor. Multiprocessor architecture.

Essential Reading:

1. K. Hwang and F. A. Briggs, ***Computer Architecture and Parallel Processing***, McGraw Hill, 3rd Ed, 2001.
2. N Carter, ***Computer Architecture***, Tata McGraw Hill, 3rd Ed. 2008.

Supplementary Reading:

1. J. L. Heressy and D. A. Pattersan, ***Computer Architecture A Quantitative approach***, Elsevier, 3rd Ed. 2006.
2. K. Hwang, ***Advanced Computer Architecture: Parallelism, Scalability, Programmability***, Tata McGraw Hill, 3rd Ed, 2004.

CS 442	COMPUTER SYSTEM ARCHITECTURE	3 credits [3-0-0]

Prerequisites: NIL

Organization of a computer, Von-Neumann stored computer architecture, Processor Organization: Information representation, Number formats, Instruction format; execution cycle, Instruction sets: Addressing modes and Formats, Fixed point arithmetic, ALU design, CPU structure and functions, Reduced Instruction set Computer: CISC Characteristics, RISC characteristics. Memory Organization: Memory technology: Memory device technology, Random access memory Virtual Memory, High speed Memory, Internal memory: semiconductor main memory, cache memory, Advanced DRAM organization, External memory, magnetic disk, RAID, Optical memory, magnetic tape. I/O organization: Bus control, Serial I/O (study of Asynchronous and synchronous modes, USART & VART), Parallel Data transfer: (Program controlled: Asynchronous, synchronous & Interrupt driven modes, DMA mode, interrupt controller and DMA controller).

Essential Reading:

1. V. Carl Hamacher, Z. G. Veranesic, and S. G. Zaky, ***Computer Organisation***, Tata Mc-Graw Hill, 5th Ed, 2002.
2. William Stallings, ***Computer Organization and Architecture Design for Performance***, Prentice Hall of India, 7th Ed, 2006.

Supplementary Reading:

1. M. Morris Mano, ***Computer System Architecture***, Prentice Hall of India, 1982.
2. J. P. Hayes, ***Computer Architecture and Organisation***, Mc-Graw Hill, 3rd Ed, 2006.
3. D. A. Pattersen and J. L. Hennesy, ***Computer Organisation and Design: The HardwareSoftware Interface***, Elsevier, 2nd Ed.

CS 443	embedded systems	4 credits [3-1-0]

Prerequisites: CS 334, CS 341, CS 242, CS 243, CS 343

Introduction: Embedded system, Processor, hardware units, software embedding, SOC, NOC, VLSI circuit; Device and Device drivers, I/O devices, timer and counting devices, serial communication using IC, LAN and advanced I/O buses between the networked multiple devices, Host system, parallel communication using ISA, PCI, PCI-X, and advanced buses, device drivers, parallel port device drivers in a system, serial port device drivers. Interrupt service handling mechanism; Software and programming concepts: processor and memory selection for embedded system, embedded programming in C++, Java and UML, multiple processes and applications, problem of sharing data by multiple tasks and routines, interprocess communication; Real time OS: OS services, I/O subsystem, Network OS, Real-time Embedded system, Need of well tested and debugged RTOS, Introduction to C/OS-II. Case Studies of programming with RTOS: Smart card embedded system, Hardware and Software co-design: specification and design of an embedded system, use of software tools for development of an embedded system.

Essential Reading:

1. R. Kamal, ***Embedded System Architecture, Programming and Design***, Tata McGraw Hill, 2005
2. R. Niemann, ***Hardware Software Codesign of Embedded System***, Kulwer Academic, 2006.

Supplementary Reading:

1. S. V. Iyer & P. Gupat, ***Embedded Real Time System Programming***, Tata McGraw Hill, 2004.
2. W. Wolf, ***Computer as Components: Principles of Embedded Computer System Design***, Elsevier, 2005
3. S. Heath, ***Embedded System Design***, 2nd Ed, Elsevier, 2005.
4. R. Mall, ***Real Time Systems Theory and Practice***, Pearson, 2008
5. F. Vahid & T. Givargis, ***Embedded Ssytem design: A unified Hardware/Software approach***, Wiley, 2007
6. G. D. Michelli & L. Benin, ***Network-on-Chip***, Morgan & Kaufman Publication, 2004.

CS 444	cluster and grid computing	4 credits [3-1-0]

Prerequisites: CS 334, CS 421, CS 332

Introduction : High Performance Computing (HPC), Grand Challenge Problems-Computational and communication intensive, Parallel Architectures-Classifications-SMP, MPP, NUMA, Clusters and Components of a Parallel Machine, Conventional Supercomputers and it's limitations, Multi-processor and Multi-Computer based Distributed Systems. **Cluster and Grids:** Cluster Components-Processor/machine, High Speed Interconnections-goals, topology, latency, bandwidth, Example Interconnect: Myrinet, Inifiniband, QsNet, Fast Ethernet, Gigabit Ethernet, Light weight Messaging system/Light weight communication Protocols, Cluster Middleware-Job/Resource Management System, Load balancing, Scheduling of parallel processes, Enforcing policies, GUI, Introduction to programming tools such as PVM, MPI, Cluster Operating Systems Examples: Linux, MOSIX, CONDOR, Characteristics of Grid, Computational services, Computational Grids, Data grids/Storage grids, management and applications, Different components of Grid-Grid fabric, Grid middleware, Grid applications and portal, Globus toolkit Ver. 2. 4, web services, MDS, GRAM, Grid Security –Cryptography, Authentication, Integrity, Digital Signature, Digital Certificates, Certificate Authority, MD-5, RSA, GSI, GSSAPI, Directory Service, LDAP, GRID FTP, GASS **Fault Tolerance:** Fault detection and diagnosis of Clusters and Grids.

Essential Reading:

1. D. Janakiram, ***Grid Computing***, Tata McGraw Hill, 2005
2. R. K. Buyya, ***High Performance Cluster Computing: Programming and Applications, Vol 2***, Prentice Hall, NJ, USA, 1999.

Supplementary Reading:

1. PankajJalote, Fault Tolerance in Distributed Systems, Prentice Hall, 1994.
2. J. J. Jos & R. K. Buyya, High Performance Cluster Computing: Architectures and Systems, Vol I, Prentice Hall, NJ, USA, 1999.

3. R. K. Buyya & C. Szyperski, ***Cluster Computing***, Nova Science, New York, USA, 2001.
4. R. K. Buyya & K. Bubendorfer, ***Market Oriented Grid and Utility Computing***, Wiley, 2008.
5. J. Jaseph & C. Fellenstein, ***Grid Computing***, Pearson, 1st Ed, 2004.

CS 445	PARALLEL ALGORITHMS	4 credits [3-1-0]

Prerequisites: CS 242, CS 332, CS 421

Modeling; Synchronous Network Model, Leader Election in a Synchronous Ring, Algorithms in General Synchronous Networks, Distributed Consensus with Link Failures, Distributed Consensus with Process Failures, More Consensus Problems, Asynchronous System Model, Asynchronous Shared Memory model, Mutual Exclusion, Resource Allocation, Consensus, Atomic Objects, Asynchronous Network Model, Basic Asynchronous Network Algorithms, Synchronizers, Shared Memory versus Networks, Logical Time Global Snapshots and stable properties, Network Resource allocation, Asynchronous Networks with Process Failures, Data Link Protocols, Partially Synchronous Models, Mutual Exclusion with Partial Synchrony, Consensus with Partial Synchrony.

Essential Reading:

1. B. Wilkinson & M. Allen, ***Parallel Programming***, Pearson, 2nd Ed, 2005
2. M. J. Quinn, ***Parallel Programming in C with MPI and OpenMP***, Tata McGraw Hill, 2003.

Supplementary Reading:

1. W. Groop, E. Lusk & A. Skjellum, ***Using MPI: Portable Parallel Programming with the Message-passing Interface***, MIT Press, 1999.
2. H. F. Jordan and G. Alaghband, ***Fundamentals of Parallel Processing***, Pearson, 1st Ed, 2003.
3. G. V. Wilson & G. Wilson, ***Practical Parallel Programming***, MIT Press, 1995.

CS 446	GRAPH THEORY	3 credits [3-0-0]

Prerequisites: CS 326, CS 332

Introduction: Graphs, Isomorphism, Walks, Paths, Circuits, Trees, Properties of Trees, Cotrees and Fundamental Circuits, Cut Sets, Fundamental Cut Sets and Cut Vertices, Planar and Dual Graphs, Metric Representation of Graphs, Coloring and covering and partitioning of a graph, chromatic number, chromatic partitioning, chromatic polynomials, matching, covering, four color problem, Directed graphs, some type of directed graphs, Directed paths, and connectedness, Euler digraphs, trees with directed edges, fundamental circuits in digraph, matrices A, B and C of digraphs adjacency matrix of a digraph,, enumeration, types of enumeration, counting of labeled and unlabeled trees, polya's theorem, graph enumeration with polya's theorem.

Graph Algorithms: Elementary Graph Algorithms, Representations of graphs, Breadth-first search, Depth-first search, Topological sort, strongly connected components

Minimum Spanning Trees: Growing a minimum spanning tree, The algorithms of Kruskal and Prim, Single-Source Shortest Paths: Shortest paths and relaxation, Dijkstra's algorithm, The Bellman-Ford algorithm, Single-source shortest paths in directed acyclic graphs, Difference constraints and shortest paths, All-Pairs Shortest Paths: Shortest paths and matrix multiplication, The Floyd-Warshall algorithm, Johnson's algorithm for sparse graphs, and A general framework for solving path problems in directed graphs, Maximum Flow: Flow networks, The Ford-Fulkerson method, Maximum bipartite matching, Preflow-push algorithms, The lift-to-front algorithm

Essential Reading:

1. T. H. Cormen, C. E. Leiserson and Ronald L. Rivest, ***Introduction to Algorithms***, Prentice Hall of India, 3rd Ed, 2006.
2. N. Deo, ***Graph Theory with Applications to Engineering and Computer Science***, Prentice Hall of India, 2004.

Supplementary Reading:

1. D. B. West, ***Introduction to Graph Theory***, 2nd Ed, Prentice Hall of India, 2007.
2. R. Diestel, ***Advanced Graph Theory***, Springer Verlag Heidelberg, New York, 2005
3. M. T. Goodrich and R. Tamassia, ***Algorithm Design: Foundations, Analysis, and Internet Examples***, Wiley, 1st Ed, 2001.

CS 448	ARTIFICIAL INTELLIGENCE & NEURAL NETWORK	3 credits [3-0-0]

Prerequisites: CS 171, CS 211, CS 332

Basic concepts of AI; Problems in AI; Applications; Production systems; Problem solving methods; Forward vs backward reasoning; Search in state spaces, state-space graph, uninformed search, heuristic search, general graph search algorithms, 2-agent games; knowledge representation using predicate calculus; rules of inference; converting arbitrary wff to conjunction of clauses, resolution reputation system; Answer extraction; Intro to expert system.

Essential Reading:

1. E. Rich and K. Knight, ***Artificial Intelligence***, Tata McGraw Hill, 2nd Ed, 1991.
2. N. J. Nilsson, ***Principles of Artificial Intelligence***, Narosa, 1986.

Supplementary Reading:

1. S. Russel and P. Norvig, ***Artificial Intelligence: a modern Approach***, Pearson, 2nd Ed, 2003.
2. D. W. Patterson, ***Introduction to Artificial Intelligence and Expert Systems***, Prentice Hall of India, 2006.

CS 449 VLSI SYSTEM DESIGN 4 credits [3-1-0]

Prerequisites: CS 243, CS 331, CS 343

Deep sub-micron digital IC design; Transistors and Devices: MOS transistors; Bipolar transistors and circuits; Fabrication: IC fabrication technology; Simulation: Modeling the MOS transistor for Circuit Simulation; Silicon-on-Insulator technology; MOS Inverter circuits: Voltage transfer characteristics; Noise margin definitions; NMOS transistors as load devices; COMS inverter. Static MOS Gate circuits: CMOS gate circuits; Complex CMOS Gates; XOR and XNOR Gates; Flip-Flops and Latches; Semiconductor memory design: MOS decoder; Static RAM cell design; SRAM column I/O circuitry; Power Grid and Clock design: Power distribution design; clocking and timing issues; Phase-locked loop/Delayed-locked loop.

Essential Reading:

1. D. A. Hodges, H. G. Jackson & R. A. Saleh, ***Analysis and Design of Digital Integrated circuits***, Tata McGraw Hill, 3rd Ed. 2008.
2. D. A. Pucknell & K. Eshraghian, ***Basic VLSI Design,*** Prentice Hall of India, 3rd Ed. 2001.

Supplementary Reading:

1. W. H. Wolf, ***Modern VLSI Design System-on-chip design***, Prentice Hall of India, 3rd Ed. 2004.
2. C. Mead & L. Conway, ***Introduction to VLSI system***, Addison Wesley, 2004.

CS 450 multimedia & COMPUTER VISION 3 credits [3-0-0]

Prerequisites: CS 171, CS 335

Image Formation and Image Models: Cameras; Radiometry – Measuring Light; Shadows and Shading; Color representation; Linear filters; Edge Detection; Pyramids and Textures; Multiple view geometry; Stereo; Optical flow; Affine structure from motion; Projective structure from motion; Calibration; Segmentation; Fitting; Linear Tracking; Non-Linear Tracking; Template Matching; Object Recognition; Case study of various applications.

Essential Reading:

1. D. A. Forsyth, J. Ponce, ***Computer Vision – A Modern Approach***, Pearson, 2005.
2. L. G. Shapiro, G. C. Stockman, ***Computer Vision***, Prentice Hall, 2001.

Supplementary Reading:

1. B. Jähne, H. Haußecker, ***Computer Vision and Applications – A Guide for Students and Practitioners,*** Academic Press, 2000.
2. R. J. Schalkoff, ***Digital Image Processing and Computer-Vision***, John Wiley and Sons, 1989.

CS 471 NETWORK LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Study of network simulator NetSimver 2. 0 and Qual Net; Simulation study of pure ALOHA protocol; Simulation study of slotted ALOHA protocol; Simulation study of Token Bus LAN protocol; Simulation study of Token Ring LAN protocol; Simulation study of WAN protocol like Frame Relay, X. 25; Implementation of shortest path routing algorithm; Study of 802. 11 wireless LAN protocols.

CS 472 SOFTWARE ENGINEERING LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

For Questions 1 – 8, do the followings:

Prepare the SRS document. You should identify the appropriate requirements for each problem.; Draw the Use Case diagrams, Domain Models, and Class Diagrams using Rational Rose.; Draw the Sequence Diagrams and Collaboration

Diagrams for each Use Case, using Rational Rose.; Draw the State Chart Diagrams and Activity Diagrams using Rational Rose, wherever necessary.; Develop the corresponding software using Java with an interactive GUI and appropriate Database.; Develop software to automate the bookkeeping activities of a 5-star hotel.; The local newspaper and magazine delivery agency wants to automate the various clerical activities associated with its business. Develop a software for this.; A small automobile spare parts shop sells the spare parts for vehicles of several makes and models. Each spare part is typically manufactured by several small industries. To streamline the sales and supply ordering, the shop owner wants to automate the activities associated with his business. Develop a software for this.; Develop a software for the automation of the dispensary of your Institute.; Develop a software for automating various activities of an Estate Office.; Develop a word processing software with some limited number of facilities such as making bold, italics, underline, cut, copy and paste etc.; Develop a graphics editor software package, using which one can create/modify several common types of graphics entities.; Develop a software for automating various activities of the department offices of your Institute.; Write a C function for searching an integer value from a large sorted sequence of integer values stored in array of size 100, using the binary search method. Build the control flow graph of this function using any compiler-writing tool. Write a program in Java to determine its cyclomatic complexity.; Write a program in Java to determine the number of defects still remaining after testing, using error seeding methodology.

CS 473 REAL TIME SYSTEMS LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Installation of RT Linux on Linux, Simulation of various scheduling algorithms such as Table driven scheduling, Cyclic scheduling, EDF scheduling, RMA etc., Comparison of the relative performances such as response time etc. of the schedulers, Develop a watch dog timer, Comparing the features of various real time operating systems such as RT POSIX, PSOS, VRTX, Vx Works, QNX, C/OS-II, Lynx, Windows CE etc., Development of a real time database.

CS 474 IMAGE PROCESSING LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Understanding the image formation; Exercise on image transformations; Assignments on image enhancement by point processing; Image enhancement in frequency domain; Understanding the concept of image degradation; Realizing different approaches of restoration; Implementation of different image compression techniques; Detection of discontinuity, edge linking, boundary detection; Region oriented segmentation; Thematically oriented project for the entire duration of the course for individual students or group of students. Laboratory works are to be done in C or MATLAB.

CS 477 SOFT COMPUTING LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Implementation of selected soft-computing methods presented during the lecture.; Implementation of various learning strategies; Realization of MLP, RBF, Hopfield networks etc; Solving optimization problems; Understanding and realizing Fuzzy Logic and Fuzzy inference; Programming Genetic Algorithms.; Understanding probabilistic reasoning, rough sets, chaos.; Realization of hybrid approaches

CS 478 PARALLEL COMPUTING LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Study of MPI and PVM; Inter-process Communication using UNIX/LINUX, Critical Section simulation; Readers/ Writers Simulation, Producers/Consumers Simulation, Implementation of semaphores; Parallel Quicksort, Matrix Multiplication using Processes; Finding Patterns in a set of files, Multithread Programming; Parallel Algorithm for Array processors, Parallel Image Processing Applications; Processor virtualization using MPI implementation,; Programming under Cluster and Grid environments

CS 479 ADVANCED LINUX PROGRAMMING LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Editing with Emacs, Compiling with GCC, Automating the Process with GNU Make, Debugging with GNU Debugger(GDB). Processes: Creating Processes, Signals, Process Termination. Threads: Thread Creation, Thread Cancellation, Thread-Specific Data, Synchronization and Critical Sections, GNU/Linux Thread Implementation . Interprocess Communication: Shared Memory, Processes Semaphores, Mapped Memory, Pipes, Sockets. Devices:

Device Types & Numbers, Device Entries, Hardware Devices & Special Devices, PTYs, and ***ioctl .*** The /proc File System: Extracting Information from ***/proc,*** Process Entries, Hardware Information, Kernel Information, Drives, Mounts, and File Systems, System Statistics. Linux System Calls: Using ***strace, access***: Testing File Permissions, ***fcntl***: Locks and Other File Operations, ***fsync***and***fdatasync***: Flushing Disk Buffers, ***getrlimit***and***setrlimit***: Resource Limits, ***getrusage***: Process Statistics, ***gettimeofday***: Wall-Clock Time, The ***mlock***Family: Locking Physical Memory, ***mprotect***: Setting Memory Permissions, ***nanosleep***: High-Precision Sleeping, ***readlink***: Reading Symbolic Links, ***sendfile***: Fast Data Transfers, ***setitimer***: Setting Interval Timers, ***sysinfo***: Obtaining System Statistics, ***uname etc. .***

CS 481 COMPILER DESIGN LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Programming with different compiler writing tools like lex and yacc, **or Flex and Bison** for object and non object oriented language. Understanding to the file structure, the tokens in which data is to be parsed, the tree in which parsed data is to be stored with lex and yacc. Compiling & running simple programs for specific problems (thermostat controller, finding the header files required for specific function used by programmers in program, designing a desk calculator, Implement an alternative grammars for infix expressions, Write a grammar for complete s-expressions; Programs relating to code generation, and register allocation: program to generate code for a specific assembler, program to identify specific control structures, inserting comments, identifying specific blocks for code partitioning. Build a lexical analyzer and a syntactic analyzer for EBNF(Students are encouraged to use some thing different like ANTLR and JAVACC); writing a simple HTML-to-TXT translator that reads from standard input text file and writes to standard output and write program that involves embellishing the parser so that it enforces some simple grammatical rules; Introduction to an Object Oriented version of YACC, Concepts to learn multiple instances of same parser which can be used concurrently or in parallel. Designing an **XML Parser,** Converting Lexacy Data to XML using a Lexer/Parser Generator, Using a Lexer/Parser Generator as a Multipurpose XML Tool Builder.

CS 482 DISTRIBUTED COMPUTING LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Familiarization with JAVA, C++, MPISIM, PVM; Client-Server Chart, TCP Simple Message Transfer; DNS using UDP, File Transfer using FTP; File Transfer using RS-232C; Implementation of RPC; Remote file reading using Sockets, Client and Server Classes; Remote data base using remote method invocation (RMI), Interface, Client and Server; Programming Clusters and Grids; Familiarization with Web Programming and Globus Tool Kits.

CS 485 ARTIFICIAL INTELLIGENCE LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Write a program to solve Traveling Salesman problem. The heuristic function used, number of nodes generated, depth of the search at each stages should be given in the form of a table; Write a program to solve 8 puzzle problem with different heuristics; Implement the alpha – beta search procedures. Use it to play the game tic-tac-toe. At the end of the game your program should give the number of nodes generated, cut-off values at each stages in the form of a table; Write an ATN interpreter. Minimize the amount of information that must be stored at each node to allow back-up; Write an Eliza like program to converse in some domain. The program should consist of two parts, a database of rules and the code that matches rules against the input and uses them to generate output. The left side of each rule should be a pattern that can be matched against a sentence input by the user. The right side should specify the response that the system will generate if the corresponding left side matches; Develop an knowledge base system consisting of facts and rules about some specialized knowledge domain of your choice; Implement Unification Algorithms. Input data sets may be any Well Formed Formulas; Write a program to schedule a meeting between five busy people using default reasoning. The output should give the time, place and day of the meeting.

CS 489 COMPUTER VISION LABORATORY 2 credits [0-0-3]

Prerequisites: NIL

Fitting a Curve, Plane, Conic Section; Implementation of linear and non-linear calibration algorithm; Surface Rendering, Shadow and Illumination; Implementation of Stereo Systems; Color constancy algorithm; Realization of different filters, implementation edge detection algorithms; Implementation of different approaches to stereopsis; Understanding Affine structure from motion; Segment based clustering; Object recognition; Individual student would be assigned a project work to be executed during the tenure of the course. C, MatLab, OpenGL softwares are to be used for this laboratory works.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

DETAILED SYLLABI OF COURSES

EC 100	Basic Electronics	3-1-0	4
EC 200	Fundamentals of Communication Systems	3-0-0	3
EC 201	Analog Electronics	3-1-0	4
EC 202	Digital Electronics	3-0-0	3
EC 203	Networks	3-1-0	4
EC 204	Semiconductor Devices	3-0-0	3
EC 232	Electrical and Electronics Measurements	3-0-0	3
EC 270	Basic Electronics Laboratory	0-0-3	2
EC 273	Circuit Simulation Laboratory	0-0-3	2
EC 274	Analog Electronics Laboratory	0-0-3	2
EC 276	Digital Electronics Laboratory	0-0-3	2
EC 300	Microprocessor	3-0-0	3
EC 301	Microprocessor	3-0-0	3
EC 311	Analog Communication Systems	3-1-0	4
EC 312	Electromagnetic Theory	3-0-0	3
EC 314	Digital Communication	3-0-0	3
EC 320	Embedded Systems	3-0-0	3
EC 322	Embedded Systems	3-0-0	3
EC 330	Process Control & Instrumentation	3-0-0	3
EC 331	Control System Engineering	3-1-0	4
EC 332	Electronics Instrumentation	3-1-0	4
EC 334	Instrumentation Devices	3-1-0	4
EC 336	Industrial Instrumentation	3-1-0	4
EC 338	Virtual Instrumentation	3-1-0	4
EC 340	Fundamentals of Digital Signal Processing	3-0-0	3
EC 341	Digital Signal Processing	3-0-0	3
EC 370	Embedded Systems Laboratory	0-0-3	2
EC 371	Microprocessors Laboratory	0-0-3	2
EC 372	Digital Communication Laboratory	0-0-3	2
EC 373	Analog Communication Laboratory	0-0-3	2
EC 374	Instrumentation Device Laboratory	0-0-3	2
EC 375	DSP Laboratory	0-0-3	2
EC 376	Virtual Instruments Lab	0-0-3	2
EC 377	Electronics Design Laboratory	0-0-3	2
EC 378	Microwave Laboratory	0-0-3	2
EC 379	PCB Design Laboratory	0-0-3	2
EC 380	Control System Lab	0-0-3	2
EC 382	Communication System Design Laboratory	0-0-3	2
EC 390	Special Laboratory in Electronics & Communication Engg - I	0-0-3	2
EC 391	Special Topic in Electronics & Instrumentation – I		3/4

EC 392	Special Topic in Electronics & Instrumentation – II		3/4
EC 393	Special Laboratory in Electronics & Instru Engg - I	0-0-3	2
EC 394	Special Laboratory in Electronics & Instru Engg - II	0-0-3	2
EC 395	Engineering Product Development Project - I	0-0-6	4
EC 396	Engineering Product Development Project - II	0-0-6	4
EC 397	Special Topic in Electronics & Communication Engg – I		3/4
EC 398	Special Topic in Electronics & Communication Engg – II		3/4
EC 399	Special Laboratory in Electronics & Communication Engg – II	0-0-3	2
EC 410	Antenna Engineering	3-0-0	3
EC 411	Coding Theory and Secure Communication	3-0-0	3
EC 412	Antenna Analysis and Synthesis	3-1-0	4
EC 413	Optical Communication	3-1-0	4
EC 414	Information Theory and Coding	3-1-0	4
EC 415	Mobile Communication	3-1-0	4
EC 416	Microwave Engineering	3-1-0	4
EC 417	Satellite Communication	3-1-0	4
EC 419	Computer Communication Network	3-1-0	4
EC 421	Digital VLSI Design	3-1-0	4
EC 423	HDL and High Level VLSI	3-1-0	4
EC 424	Embedded Computing Systems	3-1-0	4
EC 430	Industrial Electronics & Instrumentation	3-1-0	4
EC 431	PC Based Instrumentation	3-0-0	3
EC 432	Biomedical Instrumentation	3-0-0	3
EC 433	Process Control and Instrumentation	3-0-0	3
EC 434	Analytical Instrumentation	3-0-0	3
EC 437	Radar Engineering	3-0-0	3
EC 436	Biomedical Instrumentation	3-1-0	4
EC 438	Virtual Instrumentation	3-0-0	3
EC 439	Advanced Process Control	3-1-0	4
EC 440	Soft Computing Techniques	3-0-0	3
EC 442	Advanced Techniques in Digital Signal Processing	3-1-0	4
EC 443	Digital Image Processing	3-1-0	4
EC 444	Soft Computing	3-1-0	4
EC 446	Adaptive Signal Processing	3-1-0	4
EC 448	Evolutionary Computing Techniques	3-1-0	4
EC 450	Fundamentals of Digital Image Processing	3-0-	3
EC 471	Optical communication Laboratory	0-0-3	2
EC 472	Image Processing Laboratory	0-0-3	2
EC 473	High Level VLSI Laboratory	0-0-3	2
EC 474	DSP Processor Laboratory	0-0-3	2
EC 475	VLSI Laboratory	0-0-3	2
EC 476	Bio-Medical lab	0-0-3	2

EC 477	Mobile Communication Laboratory	0-0-3	2
EC 478	Antenna Design Laboratory	0-0-3	2
EC 479	Process Control Lab	0-0-3	2

For B. Tech Courses (3 or 4 level) please refer to the B. Tech Curriculum and Syllabi, for M. Tech Courses (6 level) please refer to M. Tech Curriculum and Syllabi.

EC 100 BASIC ELECTRONICS 4 credits [3-1-0]

Introduction to electronics: Signals, frequency spectrum of signals, analog and digital signals, amplifiers, frequency response of amplifiers, digital logic inverters. Linear wave-shaping circuits: RC Low pass filter, integrator; RC High pass filter, differentiator. Operational Amplifiers: Ideal OPAMP, Inverting, Adder, Integrator, Differentiation, Non-inverting applications, ADC and DAC. Diodes: The p-n junction theory, Analysis of Diode circuits, Small signal model, Different types of diodes. Bipolar Junction Transistors (BJTs): Physical structure and modes of operation, characteristics, DC Analysis, Introduction to Small Signal Analysis, Biasing Circuits. Field Effect Transistors: Structure and physical operation of Enhancement type MOSFET, Current voltage characteristic of enhancement MOSFET, depletion MOSFET, MOSFET circuits in DC, JFET and MSFET. Electronic Instruments: Ammeter, Voltmeter, Multimeter, Digital Multimeter, Cathode Ray Oscilloscopes. Fundamentals of Communication Systems: Principle of communication system, Fundamental of AM & FM, Radio & TV Transmitters and Receivers.

Essential Reading:

1. A. S. Sedra, K. C. Smith, ***Microelectronic Circuits***, Oxford University Press, India, 2005
2. A Malvino, D J Bates; ***Electronic Principles***, Tata McGraw Hill, India, (ISBN: 0-07-063424-6); 2007

Supplementary Reading:

1. R C Jaeger, T N Blalock, ***Microelectronic Circuit Design***; Tata McGraw Hill, 2006 (ISBN: 0-07-060162-3).

EC 200 FUNDAMENTALS OF COMMUNICATION SYSTEMS 2 credits [3-0-0]

Introduction to communication systems, signals and spectrum, noise, types of modulation; AM, FM, PM and radio receivers. Fourier Transform Analysis, generation and demodulation of AM and FM signals including double-sideband suppressed carrier, SSB. Frequency Division Multiplexing (FDM). Digital Modulation Techniques, Sampling theorem, pulse code modulation, delta modulation, base band transmission, transmission errors, entropy, channel capacity, A brief introduction to Optical Communication and cellular communication.

Essential Reading:

1. George Kennedy, "***Electronic Communication Systems***, " TATA McGraw-Hill Publishing House.
2. S. Haykin, ***Communication Systems***, 4^{th} ed., John Wiley & Sons, 2001

Supplementary Reading:

1. T. Schilling, "***Principles of Communication Systems***" TATA McGraw-Hill Publishing House.
2. B. P. Lathi, ***"Modern Digital and Analog Communication Systems***, " Oxford University Press
3. G. Keiser, "***Optical Fiber Communications***, " TATA McGraw-Hill Publishing House.

EC 201 ANALOG ELECTRONICS 4 credits [3-1-0]

Prerequisites: EC 100: Basic Electronics

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

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***, 6^{th} Edition, Tata McGraw Hill Edition, 2003

EC 203	NETWORKS	4 credits [3-1-0]

RESONANCE IN AC CIRCUITS: Series and parallel resonance, Characteristics, Properties of resonant circuit, Selectivity, band width and Q factor. **COUPLED CIRCUITS**: Coefficient of coupling, Dot convention, Analysis of coupled circuits. **COMPLEX WAVES**: Fourier Series Representation, Evaluation of Fourier coefficients, Wave Symmetry, RMS values of Complex waves. **IMPEDANCE FUNCTION AND NETWORK THEOREMS**: The concept of complex frequency, Transform impedance and transform circuits, Series and parallel combinations, Super-position and reciprocity, Thevenin's Theorem and Norton's Theorem, Miller Theorem, Substitution, Compensation, Milliman, Maximum Power transfer theorem, Solution of Networks consisting of linear elements (Resistance, Inductance, Capacitance) with initial condition, Active elements like voltage and currrent sources, controlled sources by using loop variable, node voltage variable, Thevenin and Norton's method in transformed domain.; **NETWORK FUNCTIONS, POLES AND ZEROS:** Network function for one port and two ports, Calculation of network functions like ladder networks, General Networks, Poles and zeros of network functions, Time domain behaviour from Pole and zero plot. **TWO PORT PARAMETERS (TRANSFORM DOMAIN):** Relation between two port network variables, Short circuit admittance, Open circuit impedance parameters, Hybrid parameters, Two generator equivalent circuit, One generator equivalent circuit, Transmission and inverse transmission parameters, Relation between parameter sets, Equalization of parameters of two port networks, Networks containing passive elements and controlled sources, Input and output impedance, transfer functions, Input output relationship, Voltage and current gain.; **NON-SINUSOIDAL PERIODIC WAVEFORM:** Waveform Synthesis, response to non-sinusoidal periodic waveform, response of the circuit to the excitation with finite number of discontinuities **NETWORK SYNTHESIS:** Definition of positive real functions, Properties of positive real function, Properties of LC, RC and RL driving point function, Synthesis of LC, RC and RL driving point functions in FOSTER I & II and CAUER I & II forms.

Essential Reading:

1. V. Valkenburg, ***Network Analysis*** PHI, 1974
2. V. Valkenburg, ***Network Synthesis*** PHI
3. Supplementary Reading:
4. F. Kuo, ***Network Analysis and Synthesis***

EC 204	SEMICONDUCTOR DEVICES	3 credits [3-0-0]

Prerequisites: EC 100: Basic Electronics

Semiconductor Crystals: Atomic Bond Model; Drift: Energy Bands, Ohm's Law, Carrier mobility; Diffusion: Current equation, Einstein's Relationship, Continuity equation; Generation & Recombination: Mechanisms, Minority Carrier Lifetime; P-N junction: Principles, DC model, Capacitance of Reverse bias PN junction, store charge effects, Metal Semiconductor contacts: Schottky diode, Mos Capacitor; MOSFET: Principles, C-V Characteristics, Second order effects; BJT: Principles, C-V Characteristics, Second order effects; IC Technology: Diode in IC Technology, MOSFET Technologies; Bipolar IC Technologies; Photonic Devices: LEDs, Photo Detectors, Solar Cells, LASERs; Microwave FETs & Diodes; Power Devices: IGBT, Thyristors.

Essential Reading:

1. S. Dimitrijev, ***Principles of Semiconductor Devices:*** Oxford University Press, 2005

Supplementary Reading:

1. Benman- ***Introduction to Semi conductor Devices –*** Cambridge. 2004
2. Dasgupta & Dasgupta, ***Semiconductor Devices*** **PHI, 2004**

EC 232	ELECTRICAL AND ELECTRONICS MEASUREMENTS	3 credits [3-0-0]

FUNDAMENTALS OF MEASUREMENT: Systems and Standards; GALVANOMETERS: Construction, Performance, Steady state and Dynamic Behaviors of d'Arsonval, Vibration, and Ballistic Galvanometers.; ELECTROMECHANICAL INDICATING INSTRUMENTS: ***Ammeters and Voltmeters:*** PMMC, Moving-Iron, and Electrodynamic type; ***Ohmmeters:*** Series-type and Shunt-type Ohmmeters; Thermo-instruments, Watt-hour Meters, Power-Factor Meters and Instrument Transformers; POTENTIOMETERS: DC and AC; BRIDGES: ***D. C. Bridges:*** Wheatstone bridge, and Kelvin bridge., ***A. C. Bridges and their Applications:*** Maxwell bridge, Hay bridge, Schering bridge, and Wein bridge, Measurement of high resistance by Megger; ELECTRONIC INSTRUMENTS FOR MEASURING BASIC PARAMETERS: Amplified DC Meter, AC Voltmeter Using Rectifiers, True RMS– Responding Voltmeter, Electronic Multimeter, ***Digital Voltmeters:*** Ramp-type, Integrating type, and Successive-Approximation type; Component Measuring Instruments: Q-meter, Vector Impedance Meter, Vector Voltmeter, RF Power and Voltage Measurements.

Essential Readings:

1. E. W. Golding, F. C. Widdis, ***Electrical Measurement and Measuring Instrument***, Wheeler Publishing, 2003
2. W. D. Cooper, A. D. Helfrick, ***Modern Electronic Instrumentation and Measurement Techniques,*** Pearson Education, 2007.

Supplementary Readings:

1. J B Gupta – ***A course in Electrical and Electronic Measurements and instrumentation;*** S K Kataria and Sons, 2003.
2. A. K. Sawhney - ***A course in Electrical and Electronic Measurements and Inst.,*** Dhanpat Rai & Sons, 2002

EC 270	BASIC ELECTRONICS LABORATORY	2 credits [0-0-3]

Familiarization with electronic components, and general purpose Laboratory equipment.; Use of CRO and function generator and calculation of amplitude, frequency, time period of different types of ac signals.; Verification of Junction Diode and Zener Diode characteristic and determination of static and dynamic resistance at the operating point.; Verification of input and output characteristics of a Bipolar Junction Transistor and determination of the operating point ad load line.; Verification of input and output characteristics of a Field Effect Transistor and determination of the operating point ad load line.; Verification of Series and Parallel Resonance theory.; Operation of diode as different form of rectifier and effect of different types of passive filters on the output.; Determination of frequency response of passive high pass and low pass filters.; Determination of frequency response of a RC coupled amplifier and determination of bandwidth and signal handling capacity.; Verification of truth table for different types of Logic gates viz. AD, OR, NAND, NOR, NOT, EX-OR with 2/ 3/ 4 inputs.; Use of OP-AMP as an inverting and non-inverting amplifier for different gains.; Introduction to circuit analysis using p-spice through frequency response study of a RC filter.

EC 274	ANALOG ELECTRONICS LABORATORY	2 credits [0-0-3]

Design of 2 stage RC coupled amplifier.; Design of integrator and differentiator using OP-AMPS.; Design and verification of different amplifier configurations with OPAMPS.; Determination of different electrical parameters of OPAMP.; Design of OPAMP application circuits using P-SPICE simulator.

EC 276	DIGITAL ELECTRONICS LAB	2 credits [0-0-3]

Static and Dynamic Characteristic of NAND and Schmitt-NAND gate(both TTL and MOS); Synthesis of a logic function by NAND gates only. (minimized and two level). Measurement of delay of the logic sp synthesized; Design a clock by using NAND gates and R-C network as well as crystal; Study the functionality of Multiplexer and using it design and implement a logic circuit; Study the principle of a Demultiplexer and implement multi-output logic circuit; Experiment on Serial-in, Parallel-in Serial-out right shift register with preset and clear. Generate maximally long linear sequence using this shift register and other necessary logic gates; Study the dynamic characteristic of a J-K flip-flop and hence find out maximum operational frequency; Design a ripple modulo counter and set-rest feedback method. Verify the states of count. Determine each stage delay and total delay. Determine the maximum clock frequency that it is able to count; Design a sequential circuit and implement it by J-K flip-flops and other related logic gates.

EC 301	MICROPROCESSOR	3 credits [3-0-0]

Pre-requisite: EC 202: Digital Electronics

INTRODUCTION TO 16 BIT MICROPROCESSORS: Architecture of 8086 CPU Architecture, Internal operations, Machine Language instructions, Addressing mode, Instruction Format, Instruction execution timing, comparison of 8088 with 8086. ASSEMBLY LANGUAGE PROGRAMMING AND INSTRUCTIONS: Assembler instruction Format, Data Transfer, Arithmetic, Branch, Flag manipulation, Logical, Shift and Rotate, String Manipulation, Stack Manipulation, Call and return instructions, REP Prefix, Segment override prefix, and simple assembler directives such as label, Variable, DB, DW, DD, EQU, END, Assume, Pointer (byte, Word, Double Word, Near, Short, and Far).; SYSTEM BUS STRUCTURE: Basic 8086/8088 configuration, Minimum Mode, Maximum Mode, System Bus timing, Interrupt Priority management with 8259 single and multiple. I/O PROGRAMMING: Fundamentals of I/O, Programmed I/O, Interrupt I/O, Block Transfer and DMA, I/O and memory configuration and design example. I/O INTERFACE: Serial communication interface using 8251, parallel communication interface using 8255, Use of 8255 for A/D and D/A conversion with examples, Programmable timer and event counter using 8254, its application to ADC, Key board and display controller using 8279,; A SIMPLE PROCESS CONTROL MODEL USING 8086/8088 IN MAXIMUM AND MINIMUM MODE.; ASSEMBLY LEVEL PROGRAMMING: Directives and operators, Linking and relocation, Near and far procedure, external identifiers and procedures. INTRODUCTION TO Multiprogramming. INTRODUCTION TO Multiprocessor configuration. INTRODUCTION TO 80286, 80386, 80486, 80586 (Pentium) MICROPROCESSOR Introduction, Architecture, internal operations, Addressing modes, instructions sets (brief)

Essential Readings:

1. W. A. Triebel and A. Singh, ***The 8088 and 8086 Microprocessor Programming: interfacing Software and hardware applications,*** 2002, PHI.
2. B. B. Brey, ***The Intel microprocessor: 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and Pentium processor,*** 2002, Pearson Education India

Supplementary Readings:

1. Liu and Gibson; ***Microprocessor Systems: The 8086/8088 Family: Architecture, Programming and design***, PHI

EC 311	ANALOG COMMUNICATION SYSTEMS	4 credits [3-1-0]

SPECTRAL ANALYSIS: Fourier series, Response of a linear system, Normalized power in a Fourier expansion, Power spectral density. The Fourier transform, Convolution, Parseval's theorem, Power and energy transfer through a network, Auto and Cross correlations. **RANDOM VARIABLES AND PROCESSES:** Probability, Mutually exclusive events, Joint probability, Statistical independence, Random variables, Probability density function, Average and variance. The Gaussian probability density. The error function, Mean and Variance of sum of random variables, Probability density of Z = X+Y. The Central limit theorem, correlation between random variables, auto correlation, power spectral density. **AMPLITUDE MODULATION SYSTEMS:** Frequency translation, Recovery of base band signal, Amplitude Modulation, Maximum Allowable Modulation. The square Law demodulator, Spectrum of AM signal, Balanced Modulator, SSB modulation and generation, VSB, FDM. **FREQUENCY MODULATION SYSTEM:** Phase and frequency modulation and their relationship, Frequency deviation, spectrum of FM Signal, BW of FM signal, Effect of modulation on BW, constant BW, FM phasor diagram, Narrow band FM, Armstrong and Parameter Variation methods of FM generation. FM

Demodulators. **ANALOG TO DIGITAL CONVERSION**: Pulse Modulation Systems, Sampling theorem, Pulse Amplitude Modulation, Quantization of signals, Quantization error, Pulse code modulation (PCM) system, Companding, Time division multiplexing (TDM), DPCM, DM, ADM. **NOISE IN COMMUNICATION SYSTEM:** Resistor noise, Available power, Noise temperature, Noise bandwidth, Two ports Noise bandwidth, Input Noise temperature, Noise figure, Equivalent-Noise temperature of a cascade, An example of receiving system.

Essential Reading:

1. H. Taub, D. L Schilling, G. Saha, ***Principles of Communication System, 3rd Edition; 2008, Tata McGraw Hill, India;*** ISBN: 0070648115.

Supplementary Reading:

1. A. B. Carlson, ***Communication system -*** by Mc. Graw Hill.
2. G. P. John, S. Masoud, ***Communication Systems Engineering,*** Second Edition; 2002; PHI, India; ISBN : 81-203-2750-0

EC 312	ELECTROMAGNETIC THEORY	3 credits [3-0-0]

Laplace and Poisson's equation, Solution of Laplace equation by separation of variables in Cartesian, cylindrical and spherical co-ordinates, cylindrical and spherical harmonics, Examples.; Maxwell's equations for static fields, their modifications for time-varying fields conducting and dielectric media.; EM Wave equations and uniform plane waves, in free space and in lossy medium, wave propagation in good dielectrics, in good conductors: Depth of penetration, Poynting vector and power flow, Reflection and refraction of EM Waves.; Transmission lines: Transmission line equations, Parameters- primary and secondary constants, Reflection coefficient and SWR, Matched Transmission line, Impedance matching, Smith chart problems, Analogy of transmission lines with e. m. waves.; Guided waves and Waveguides: Electric and magnetic fields in rectangular waveguide; TE, TM and TEM modes, Dominant modes, λ_c, λ_g, v_p, v_g, Numerical examples.; Radio Wave Propagation: Modes of propagation, Structure of Troposphere, Tropospheric+-* Scattering, Ionosphere, Ionospheric Layers - D, E, F_1, F_2, regions. Sky wave propagation - propagation of radio waves through Ionosphere, Effect of earth's magnetic field, Virtual height, Skip Distance, MUF, Critical frequency, Space wave propagation.

Essential Reading:

1. N. Ida***, Engineering Electromagnetics, Springer, 2004***
2. E. C. Jordan and K. G. Balmain, ***Electromagnetic waves and Radiating systems, Prentice hall, 2004***

Supplementary Reading:

1. M. N. O. Sadiku, ***Elements of Electromagnetics-*** Oxford University Press, 2006
2. W. H. Hayt***, Engineering Electromagnetics, McGraw Hill, 2007***

EC 314	DIGITAL COMMUNICATION.	3 credits [3-0-0]

Prerequisites: EC 311: Analog Communication Systems

DIGITAL MODULATION TECHNIQUES: BPSK, BFSK and DPSK, QPSK, M-ary PSK, MSK, M-ary FSK, GMSK. **OPTIMUM RECEIVERS FOR AWGN CHANNEL**: Optimum receiver for signals corrupted by AWGN, performance of optimum receiver for memory less modulation, optimum receiver for CPM signals, optimum receiver for signals with random phase in AWGN channel. **CARRIER AND SYMBOL SYNCHRONIZATION:** Signal Parameter estimation, carrier phase estimation, symbol timing estimation, Joint estimation. **CHANNEL CAPACITY AND CODING**: Channel models and channel capacity, Block codes – coding and decoding, cyclic codes, algebraic codes, Reed-Solomon Code, Convolutional codes; **SPREAD SPECTRUM SIGNALS FOR DIGITAL COMMUNICATION:** Direct sequence (DS) spread spectrum and its applications, frequency hopping (FH) spread spectrum, synchronization of spread spectrum systems.

Essential Reading:

1. H. Taub and D. L. Schilling, ***Principle of Communication Systems***, 2nd Ed., McGraw Hill, 1986.
2. J. G. Proakis, ***Digital Communication,*** McGraw-Hill Publications, 2000.

Supplementary Reading:

1. B. Sklar, ***Digital Communications***, Pearson Education, India, 2001
2. J. G. Proakis, M. Salehi, ***Communication Systems Engineering***, Pearson Education International, 2002
3. Lee & Moseschmitt, ***Digital Communication,*** Springer, 2004.

EC 316 MICROWAVE ENGINEERING 4 credits [3-1-0]

Prerequisites: EC 312: Electromagnetic Theory

Introduction: Microwave frequencies, Standard Frequency bands, Behaviour of circuits at Conventional and microwave frequencies, Microwave application, Review of Maxwell's equations; Waveguide: Overview of guided waves; TE, TM and TEM modes, circular wave guide, Choice of the type of waveguide dimensions, waveguide problems.; Microwave Components & Devices : Scattering matrix and its Properties, coupling probes, coupling loops, windows, Waveguide tuners, Termination, E-plane Tee, H-plane Tee, Magic Tee, Phase-Shifter, attenuators, Directional coupler, Gunn diode, Microwave transistor MASER, Resonator and circulators.; Microwave Generators: Transit-time effect, Limitations of conventional tubes, Two-cavity and multi-cavity Klystrons, Reflex Klystron, TWT and Magnetrons.; Microwave Measurements : Power measurement; Calorimeter method, Bolometer bridge method, thermocouples, Impedance measurement, Measurement of frequency and wavelength, Measurement of unknown loads, Measurement of reflection coefficient, VSWR and Noise, Microwave test bench.

Essential Reading:

1. D M Pozar, ***Microwave Engineering***, John Wiley & Sons, 2004
2. S Liao, ***Microwave Devices & circuits***, Prentice halls, India, 2004

Supplementary Reading:

1. M L Sisodia, V. L. Gupta, ***Microwaves: Introduction to Circuits, Devices and*** Antennas, New Age, 2001
2. R E Collin, ***Foundations of Microwave Engg***. McGraw-Hill 2001

EC 322 EMBEDDED SYSTEMS 3 credits [3-0-0]

INTRODUCTION TO 8-bit and 16 bit microcontroller: 8051 family of microcontroller, architecture, memory organization, special function registers, timer counter, serial interface, interrupt organization, instruction sets and programming, instruction timing and interfacing, practical applications, introduction to 16-bit microcontroller 8096; INTRODUCTION TO Embedded systems, Processor and memory organization, Devices and Buses for device networks, Device drivers and Interrupt servicing mechanism, Programming concepts and Imbedded programming in C and C++, Program modeling concepts in single and multiprocessor- development Process, Real time operating system.

Essential Readings:

1. R. Kamal, ***EMBEDDED SYSTEMS Architecture, Programming and Design,*** Tata McGraw-Hill Publishing Company Limited, 2003.
2. M. A. Mazdi & J. G. Mazdi, ***The 8051 Microcontroller and Embedded System,*** Pearson Education India, 2005.

Reference Readings:

1. K J Ayala, ***The 8051 Microcontroller Architecture, Programming and Application***, Penram International Publishing (India), 2004.
2. T. D Morton, ***Embedded Microcontrollers***, Pearson Education, India, 2003.

EC 331 CONTROL SYSTEMS ENGINEERING 4 credits [3-1-0]

INTRODUCTION; MATHEMATICAL MODEL: Mathematical representation of physical systems, Transfer function and impulse response of linear systems, Block diagram, Signal flow graphs; CONTROL SYSTEM COMPONENTS: Potentiometer, Synchros, LVDT, modulators, demodulators, ac servo motors, ac and dc tacho generators, HYDROULIC SYSTEMS and PNEUMATIC SYSTEMS; GENERAL FEEDBACK THEORY: Feedback, The effect of feedback, Mathematical definition of feedback; TIME RESPONSE OF FEEDBACK CONTROL SYSTEMS: Typical test signal for the transient analysis, time domain performance characteristics, transient response, PI, PD Controllers, Tacho meter feedback, Steady state response, steady state error, The generalized error analysis, Stability, The Routh-Hurwitz criterion; THE FREQUENCY RESPONSE METHOD: Bode's Plot, Frequency domain specifications, M_p and ω_p for a second order system; THE NYQUIST CRITERION AND STABILITY: Nyquist criterion and the GH Plot, Relative stability, gain margin, phase margin, conditionally stable systems; THE ROOT LOCUS TECHNIQUE: Introduction, Root Locii, Root locus of conditionally stable systems; STATE VARIABLE ANALYSIS: Introduction, state, state variable and state model, State equations of continuous data control system, Derivation of state model from transfer functions and Vice-versa. Diagonalisation, solution of state equation.

Essential Readings:

1. K. Ogata, ***Modern Control Engineering***, 2001, Prentice Hall of India.
2. N. S. Nise, ***Control system engineering***, 1992, John Wiley & Sons.

Supplementary Readings:

1. B. C. Kuo, ***Automatic Control System, 1995,*** PHI.
2. J. Diazzo and C. F. Houpis, Feed back ***Control system analysis and synthesis.***

EC 332 ELECTRONIC INSTRUMENTATION 4 credits [3-1-0]

Pre-requisite: EC 100: Basic Electronics

REVIEW OF MEASUREMENTS AND ERROR: Definition, accuracy and precision, Significant figures, Types of error, Statistical analysis, Probability of error, limiting error; CATHODE RAY OSCILLOSCOPE: Introduction, Block diagram of CRO, cathode ray tube, CRT circuits, Vertical deflection system, delay line, horizontal deflection systems, Multiple trace, Oscilloscope probes and transducers, Measurements with CRO, special oscilloscope.; SIGNAL GENERATION: Sine-wave generator, Frequency synthesized signal generator, Frequency divider generator, Sweep frequency generator, pulse and square wave generator, Function generators, Audio frequency signal generator, Digital and Analog Noise generator SIGNAL ANALYSIS: Wave analyser, Distortion analyser and spectrum analyser; FREQUENCY AND TIME INTERVAL MEASUREMENT: Simple frequency counter, measurement error, extending frequency range of counter, Automatic computing counter, Measurement of higher frequency by wave meter, heterodyne freq. meters; ANALOG AND DIGITAL DATA ACQUISITION SYSTEMS: Introduction, Signal conditioning of input, Single channel data acquisition systems, Multi channel data acquisition systems, Data conversion, A/D and D/A converters, Multi-plexers, Sample and hold circuits; INPUT OUTPUT DEVICES AND DISPLAY: Introduction, Analog displays and recorders, Digital I/O devices, Displays, Display multiplexing, Zero suppressing.

Essential Readings:

1. A. D. Helfrick, W. D. Cooper, ***ModernElectronic Instrumentation and Measurement Techniques***, PHI, New Delhi, 2002.
2. D. A. Bell, ***Electronic Instrumentation and Measurement,*** PHI, New Delhi, 2003.

Supplementary Readings:

1. C. S. Rangan, G. R. Sarma and V. S. V. Mani, ***Instrumentation Devices and Systems,*** TMH, 2000
2. H. S. Kalsi, ***Electronic Instrumentation,*** TMH, 2000.
3. D. Patranabis, ***Principles of Electronic Instrumentation***, PHI, 2008.

EC 334 INSTRUMENTATION DEVICES 4 credits [3-1-0]

THE GENERAL MEASUREMENT SYSTEM: Measurement System – Purpose, structure and elements. STATIC CHARACTERISTICS OF MEASUREMENT SYSTEM ELEMENTS: Systematic characteristics, Generalised Model of System element, statistical characteristics. THE ACCURACY OF MEASUREMENT SYSTEM IN THE STEADY STATE: Measurement error of a system of ideal elements. The error probability density function of a system of non-ideal elements. Error reduction techniques. DYNAMIC CHARACTERISTICS OF MEASUREMENT SYSTEMS: Transfer function for typical system elements, step and frequency response. Dynamic errors in measurement systems. Techniques for dynamic compensation. LOADING EFFECTS IN MEASUREMENT SYSTEM: Electrical loading, Generalised loading. SIGNAL AND NOISE IN MEASUREMENT SYSTEM: Statistical representation of random signals: Effects of Noise and interference on Measurement circuits, Noise sources and coupling mechanism, Method of reducing effects of Noise and interference. SENSING ELEMENT: Resistive (Potentiometers, Resistance Thermometer, Strain Gauges), Inductive (Variable reluctance, LVDT), Capacitive, Electromagnetive, Thermoelastic, Elastic, Piezoelectric, Photoelectric, Hall effect, Synchors and Resolvers, Digital Displacement Eddy current. SIGNAL CONDITIONING CIRCUITS: Potentiometer Circuit (Constant voltage and constant current), Wheatstone Bridge (Constant voltage and constant current).

Essential Readings:

1. J. P. Bentley, ***Principles of Measurement System, Pearson Education***, Third edition, 2003.

Supplementary Readings:

1. J. W. Dally, W. F. Riley, K. G. McConnell, ***Instrumentation for Engineering Measurements***, John Wiley, 2001.
2. J. B. Gupta, ***A course in Electronic and Electrical Measurements and Instrumentation***, S. K. Kataria and Sons, 2000.

EC 336 INDUSTRIAL INSTRUMENTATION 4 credits [3-1-0]

Pre-requisite: EC 334: Instrumentation Devices

CHARACTERISTICS OF MEASUREMENT SYSTEMS: Introduction, Classification, Performance characteristics, Errors; PRESSURE MEASUREMENT: Basic methods, Measurement of mid-range pressures – U-tube manometer, Dead-weight gauge, Diaphragm, Bellows, Bourdon tube; Low-pressure measurement – Thermocouple gauge, Pirani gauge, Thermistor gauge, McLeod gauge, Ionization gauge; High-pressure measurement; TEMPERATURE MEASUREMENT: Introduction, Thermal expansion methods – Liquid-in-glass thermometer, Bimetallic thermometer, Pressure thermometer; Thermoelectric-effect instruments – Thermocouples; Varying-resistance devices – Resistance thermometers, Thermistors; Radiation thermometers – Optical pyrometers, Radiation pyrometers; FLOW MEASUREMENT: Introduction, Obstruction type flow meters, Variable-area flow meters, Positive-displacement flow meters, Turbine meters, Electromagnetic flow meters, Vortex-shedding flow meters, Ultrasonic flow meters; LEVEL MEASUREMENT: Dipsticks, Float systems, Pressure-measuring devices, Capacitive devices, Ultrasonic level gauge, Radiation methods, Hot-wire elements.

Essential Readings:

1. E. O. Doebelin, ***Measurement Systems, Application and Design,*** McGraw Hill International Edition, Singapore, 2003.
2. D. Patranabis, ***Principles of Industrial Instrumentation,*** Tata McGraw Hill, New Delhi, 2000.

Supplementary Readings:

1. B. C. Nakra and K. K. Chaudhury, ***Instrumentation Measurement and Analysis***, Tata McGraw Hill Publishing Company Ltd., 2003.
2. A. K. Ghosh, ***Introduction to Instrumentation and Control***, PHI, 2000.

EC 338	VIRTUAL INSTRUMENTATION	4 credits [3-1-0]

Pre-requisite: EC 334: Instrumentation Devices

FLOW MEASUREMENT SYSTEMS: Measurement of velocity at a point in a fluid, pitot-static tube, Measurement of volume flow rate: differential pressure, mechanical and vortex flow meters, Measurement of mass flow rate, inferential and direct methods, Measurement of flow rate in difficult situations: electromagnetic and cross-correlation flow meters. OPTICAL MEASUREMENT SYSTEMS: Introduction, types of systerm, Source: Principles, hot body, LED and Laser sources, Transmission medium: principles, optical fibers, Geometry of coupling of detector to source, Detectors and signal conditioning elements: thermal and photon detectors, Measurement systems: intensity and wave length modulation, interferometers. GAS CHROMATOGRAPHY: Principles and basic theory, typical gas Chromatograph, Signal processing and operations sequencing. DIGITALTIME MEASUREMENT TECHNIQUES: DIGITAL FREQUENCY MEASUREMENT TECHNIQUES: DIGITALLY PROGRAMMABLE CIRCUITS.

Essential Readings:

1. J. P. Bentley, ***Principles of Measurement Systems***, Pearson Education, 3rd Edition, 2003.
2. T. S. Rathore, ***Digital Measurement Techniques***, Narosha Publishing Home, 2001.

EC 341	DIGITAL SIGNAL PROCESSING	3 credits [3-0-0]

Introduction: Signals, systems and signal processing, concept of frequency in continuous and discrete time signal; **Discrete-time Signals and Systems:** Discrete time signals and systems, analysis of LTI system and implementation, correlation; **Z-transform:** Review, Analysis of LTI system in z-domain.; **Frequency Domain Analysis:** Frequency analysis of continuous-time and discrete-time signals and LTI systems, LTI system as frequency selective filter, inverse system and de-convolution.; **Discrete Fourier Transform:** Properties and Applications, Analysis using DFT; **Fast Fourier Transform Algorithms:** FFT algorithms and Applications, linear filtering approach to computation of DFT; **Implementation of Discrete-Time System:** FIR system, IIR system, representation of numbers, quantization of filter coefficients, round-off effects; **Design of Digital Filters:** Design of FIR and IIR filters, **Recent Developments.**

Essential Reading:

1. J. G. Proakis and D. G. Manolakis, ***Digital Signal Processing: Principles Algorithms and Applications***, Pearson Education, 2005

Supplementary Readings:

1. A. V. Oppenheim, R. W. Schafer, ***Digital Signal Processing***, Pearson Education, 2004
2. S. K. Mitra - ***Digital Signal Processing: A computer based approach***, TMH, 2001
3. L. R. Rabiner and B. Gold, ***Theory and Application of Digital Signal Processing,*** Pearson Education, 2004

EC 370	EMBEDDED SYSTEM LAB	2 credits [0-0-3]

Microcontroller architecture. overall hardware architecture of microcontrollers, including busses, memories, and input/output subsystems. Application of timer and A/D subsystems to solve measurement and control tasks. Microcontroller interfacing. derive waveforms for serial communications interfaces. Apply microcontrollers and external circuitry to interface to a variety of sensors and actuators; Applications: Traffic light control using micro controller; Stepper motor control using micro controller; Downloading and uploading from /on PC memory; Structured approach and developing an embedded system (Mini Project); Initial Planning; Detailed hardware planning: Software Development; Instruction details; Future Improvements.

EC 371	MICROPROCESSOR LABORATORY	2 credits [0-0-3]

Arranging a set of date in ascending and descending order; Finding out the number of positive, negative and zeros from a data set; Transfer of data from one memory location to another memory location; Searching the existence of a certain data in a given data set; Gray – to – Binary and Binary – to – Gray conversion and BCD – to – Binary and Binary – to – BCD Conversion; Design a Up/down Counter; Multiply two 8 Bit numbers using Successive addition and shifting method; Add a series of unsigned 8- Bit data. Extend the experiment to add signed number and multi byte numbers; Generate a Square wave and rectangular wave of given frequency at the output pin of 8255 chip; Finding out 10's complement of a 4- digit BCD number; Add a series of Decimal numbers; Division of 8 Bit unsigned numbers by two. Division of a unsigned numbers by two; Disassembling of the given 2 digit decimal number into two nibbles; Transmission of series data by using SOD lines; Generation of different types of analog signal using DAC; Sampling of analog signal using ADC; A small project work for construction of a display system/ real time digital clock.

EC 372	DIGITAL COMMUNICATION LABORATORY	2 credits [0-0-3]

To study Time division multiplexing; To study PCM; To study the different channel coding and decoding technique; Generation and reception of different types of signals like ASK, PSK, FSK; To transmit and receive three separate signal audio, video, tone simultaneously through satellite link; To transmit PC data through satellite link using a satellite communication demonstration unit; Experimentally compare different forms of BPSK, QPSK, OQPSK and analyze their spectrum with spectrum analyzer; Spreading and dispreading using additive white Gaussian noise generation/ Gold code and other forms of spreading techniques; Transmit different types of signals suing a ISDN system; Analyze the process of data communication in LAN using LAN trainer and compare the performance different media access techniques.

EC 373	ANALOG COMMUNICATION LABORATORY	2 credits [0-0-3]

Study and design of AM modulator and demodulator. (Full AM, SSB, DSBSC, SSBSC); Study of FM modulation and Demodulation Techniques; Observer the process of quantization and determination of quantization noise; Using MATLAB generate a carrier and a modulating signal Modulate the carrier using AM. Show the waveform in time domain and analyze its frequency spectrum. Repeat the simulation for modulating signal being square, triangular and other forms waveform; Using MATLAB generate a carrier and a modulating signal Modulate the carrier using FM. Show the waveform in time domain and analyze its frequency spectrum. Repeat the simulation for modulating signal being square, triangular and other forms waveform; Using Lab-View software simulate AM modulation and demodulation system; Using Lab-View software simulate FM modulation and demodulation system; Design a receiver to demodulate and receive the signal from a AM radio station; Design a receiver to demodulate and receive the signal from the local FM radio station.

EC 374	INSTRUMENTATION DEVICE LABORATORY	2 credits [0-0-3]

Determination of Temp. -Resistance & Temp. —Voltage characteristics of the Thermistor; Determination of Temp. -Resistance & Temp. —Voltage characteristics of the RTD (pt-100); Determination of Temp. using Thermocouple with compensation & without compensation . Plot the graph for Actual Temp. vs %Error; Determination of characteristics between strain applied & the voltage output, as well as the signal conditioned voltage of a cantilever strain gauge; To study the characteristics of a LVDT with respect to secondary output voltage & Signal conditioned output voltage. Calibrate the LVDT & plot the graph between displacement & % Error; To study the response of optical sensor by varying the distance from light source; Study of PID controller; Study of Temperature control system.

EC 375	DSP LABORATORY	2 credit [0-0-3]

Write a program for linear convolution of two sequences; Write a program for circular convolution; Write a program to perform linear convolution using circular convolution; Write a program to perform N-point DFT. Also perform the IDFT on the result obtained to verify the result; Write a program to perform circular correlation using: Direct method b) circular convolution using rotation method; Write a program to perform circular convolution and correlation using DFT; Write a program to perform linear convolution using (a)overlap save method (b) overlap add method; Write a program to perform FFT on a sequence using the following methods. (a) Decimation in time (b) Decimation in frequency; Write a program to perform IDFT on a transformed sequence using DFT; Write a program to design an FIR filter using windowing technique; Write a program to design an IIR filter using (a) impulse invariant method (b) bilinear transformation method.

EC 376	VIRTUAL INSTRUMENTATION LAB	2 credit [0-0-3]

Water Level Control by PLC model IM-23; Elevator Control by PLC model IM-20A; Temperature Control by PLC Trainer model IM-30; Performance analysis of Accelerometer; To study the characteristics of the Hall effect through the Hall sensors; Experiment based on Mechatronics Trainer System; Experiments on PLC Trainer Model VPLCT-02S.

EC 378	MICROWAVE LAB	2 credit [0-0-3]

Using Gunn Oscillator Based Microwave Test bench: Study of Gunn Oscillator; Study of Frequency, Guide wavelength; Measurement of VSWR, Reflection coefficient, Impedance measurement; Study of Directional coupler; Study of Variable Attenuator; **Using Microwave Test bench for Antenna Measurement:** To plot the polar pattern & gain characteristics of the following Antennas; Pyramidal Horn; Pickup Horn; Slotted Horn; Slotted Wave Guide Antenna; Dielectric Antenna; Sectorial Horn (E & H-Plane); Parabolic Dish; **Using IE3D & WIPLD Electromagnetic Simulator:** Simulation of Microstrip patch Antenna to study the following parameters; Impedance Plot; Radiation pattern; Bandwidth; S-parameters($S_{11,}$ $S_{12,}$ S_{22} etc).; Gain; Efficiency

EC 380	CONTROL SYSTEM LAB	2 credit [0-0-3]

Evaluate the effect of pole and zero location on the time response of first and second – order systems; Evaluate the effect of additional pole and zeros on the time response of second- order systems; Verify the equivalency of the basic forms, including cascade, parallel and feedback forms. To verify the equivalency of the basic moves, including moving blocks past summing junctions and moving blocks past pickoff points; Verify the effect of pole location upon stability of a system. Extend the experiment to check the stability with negative feedback; Verify the effect of input waveform, loop gain and system type upon steady-state errors; See the effect of open-loop poles and upon the shape of the root locus. Also verify the root locus as a tool for estimating the effect of open-loop gain upon the transient response of closed-loop systems; To perform a trade-off study for lead compensation. To design a PI controller and see its effect upon steady- state error; To examine the relationships between open-loop frequency response and stability, open-loop frequency response and closed-loop transient response and the effect of additional closed-loop poles and zeros upon the ability to predict closed-loop transient response; To design a PID controller using MATLAB's SISO design tool. Observe the effect of a PI and a PD controller upon the magnitude and phase responses at each step of the design of a PID controller; To simulate a system that has been designed for transient response via a state- space controller and observer; Design the gain of a digital control system to meet a transient response requirement; to simulate a digital control system to test a design and observe the effect of sampling rate upon the time response of a digital system.

EC 382	COMMUNICATION DESIGN LAB	2 credit [0-0-3]

Design a AM transmitter and receiver system using p-spice and test the circuit designed using discrete components; Design a FM transmitter and Receiver system using p-spice and test using discrete components; Design a 10m FM transmitter using available ICs and receive the transmitter signal using a commercial FM receiver; Design a PCM system to transmit voice signal. Include multiplexing of 8voice channels for the purpose and design the receiver side also design a delta modulator for voice signal transmission.

EC 410	ANTENNA ENGINEERING	3 credits [3-0-0]

Prerequisites: EC 312: Electromagnetic Theory

Electromagnetic fields and its radiation: Maxwell's equations, EM Waves, Plane wave equation and its solution for free space and non-conducting medium. **Structures of Antennas:** Antenna Definition, size, supports, feeders, conductors & insulators. **Antenna Parameters**: Isotropic radiator, Radiation resistance, Antenna resistance, Bandwidth, Beamwidth, Radiation pattern, Radiation intensity, Gain - Power gain Directive gain, Directivity, Antenna aperture, Efficiency, Effective aperture, effective length, Polarization, Voltage and Current relations. **Practical Antennas:** VLF & LF transmitting antennas, Medium frequency and High frequency antennas, Long wire, Rhombic, V, Folded - dipole, Yagi, Horn and Parabolic reflector. **Planar Antenna:** Microstrip Antenna, Radiation Principle, Input impedance, Bandwidth, Feeding techniques, TL model, Cavity Model, Parameter calculation using IE3D software.

Essential Reading:

1. C Balanis, ***Antenna theory, analysis and design***, 2nd. Edn., John Wiley & Sons.

Supplementary Reading:

1. E. C. Jordan & K. G. Balmain, ***Electromagnetic waves and Radiating Systems.***
2. R. Chatterjee, ***Antenna Theory and Practice*** - New age Publisher, 2004.

3. J. D. Kraus, ***Antenna***- Tata McGraw Hii, 2006.

EC 412	ANTENNA ANALYSIS & SYNTHESIS	4 credits [3-1-0]

Pre-requisite: EC 312: Electromagnetic Theory

Design of short wire antenna, Calculation of field pattern for odd and even Half- wavelengths Antenna Array, Linear array, Phased array; Array synthesis: Prediction of antenna array from radiation pattern, Detailed theoretical analysis of: Yagi-Uda array; Theory of: Horn antenna, Parabolic antenna, satellite antenna; Design of Microstrip antenna (Rectangular & square patches); Idea about Transmission Line Model; Brief idea about Active Integrated antenna

Essential Reading

1. C. A. Balanis, ***Antenna Analysis.***

Supplementary Reading

1. Jordan & Balmain, ***Electromagnetic Waves and Radiating Systems.***
2. J. D. Kraus, ***Antenna Theory.***

EC 413	OPTICAL COMMUNICATION	4 credits [3-1-0]

Introduction to optical communication: Characteristics of optical transmission media, optical fibres- preparation and transmission characteristics, loss and dispersion mechanisms; **Optical sources:** principles of operation, modulation characteristics and driver circuits, LED, laser diodes, light source linearity, modal, and partition and reflection noise**;** **Power Launching and Coupling:** Source to fibre power launching, lensing schemes for coupling improvement, fibre to fibre joints, couplers, multiplexers and splices; **Photo detectors**: principles of operation, circuits and performance, preamplifiers and post-detection amplifiers; **Optical Fiber systems**: intensity modulation/direct detection system, link budget using direct detection, coherent system, wavelength converters, coherent and WDM systems, Photonic switching.

Essential Reading:

1. G. Keiser, ***Optical Fibre Communications***, McGraw Hill, 2008.
2. John M. Senior, ***Optical Fiber Communications: Principles and Practice***, PHI, 2008.

Supplementary Reading:

1. Jones, William B. Jones, ***Introduction to Optical Fiber Communications Systems***, Oxford University Press (1995)
2. A. J. Rogers, ***Understanding Optical Fiber Communications***, Artech House (2001)
3. J. C. Palais, Fiber optic communication, 5th edition, Prentice Hall, 2004

EC 414	INFORMATION THEORY AND CODING	4 credits [3-1-0]

Introduction: Entropy and mutual information, source coding, variable length coding, discrete memory less channels, capacity cost functions, channel coding, linear block codes, and cyclic codes. Convolution codes, sequential and probabilistic decoding, majority logic decoding, burst error-correcting codes, turbo codes and low-density-parity-check codes; rate distortion theory: rate distortion function. **Cryptography**: basic concepts on cryptography and cryptoanalysis, security issues; private-key encryption algorithms-stream ciphers, block ciphers, Shannon's theory; introduction to number theory - modular arithmetic, exponentiation and discrete logarithms in Galois field; public-key encryption algorithms-Diffie-Hellman public-key distribution scheme, RSA public-key cryptosystem; Message authentication, hashing functions, digital signatures.

Essential Reading:

1. S. Haykin, ***Communication Systems***, 4th Ed, John Wiley & Sons, New York, 2001.
2. L. Hanzo, T. H. Liew and B. L. Yeap, ***Turbo coding, turbo equalization and space-time coding for transmission over fading channels***, John Wiley & Sons, 2002

Supplementary Reading:

1. Wade Trappe, Lawrence C. Washington, ***Introduction to Cryptography with Coding Theory***, Second edition, Prentice-Hall, Inc. NJ, USA.
2. R. Bose, ***Information Theory, Coding and Cryptography***, Tata McGraw-Hill, 2002.
3. B. P. Lathi, ***Modern digital and Analog communications,*** Third Edition, Oxford University Press.
4. Douglas R. Stinson, Cryptography***: Theory and Practice***, Third Edition, Champmen & Hall/ CRC.

EC 415 MOBILE COMMUNICATION 4 credits [3-1-0]

Evolution, Mobile Systems around the World, Example of the mobile radio systems, recent trends, Frequency reuse, Channel assignment, hand off process, Interference. Path less: – Radio wave propagation, diffraction, Scattering, link budget; Outdoor and indoor propagation models; Principle of multi path propagation, Impulse response model of channels, parameters for mobile multi path channels, concept of fading, Rayleigh and Ricean fading; simulation of fading channels. Modulations techniques for mobile communication: - Linear Modulation techniques, constant envelop modulation, QPSK, MSK, GMSK, spread spectrum modulation techniques. Equalization: - Fundamentals, General adaptive equalizer, Linear and non-linear equalizers, diversity techniques, RAKE receivers. Basic concept of coding. Multiple access techniques: - Introduction, FDMA, TDMA, CDMA, Space division multiple access, capacity of cellular systems. Introduction to OFDM and wireless LAN.

Essential Reading:

1. T. S. Rappaport, ***Wireless Communications – Principles and Practice***, Prentice Hall of India/ Pearson Education India, 2002.
2. W C Y Lee, ***Mobile Communication Engineering***, Tata McGraw Hill, India, 2008

Supplementary Reading:

1. W. C. Y. Lee, ***Digital Cellular Systems***, Mc Graw Hill, 2000.
2. G. Stuber, ***Principles of Mobile Communication***, 2001, Springer

EC 417 SATELLITE COMMUNICATION 4 credits [3-1-0]

Introduction: Original Satellite Communications, History, Current State, Overview of Satellite System Engineering; **Orbital Aspects of Satellite Communication:** Orbital mechanism, look angle determination, orbit determination, orbit effects on Communication, System performance; **Satellite Link Budget:** Basic transmission theory, system noise and G/T ratio, down link design, satellite system using small earth station, up-link design; **Modulation Multiplexing Techniques:** Analog telephone transmission, Television transmission, Digital transmission, Digital TV and bandwidth Compression, time division multiplexing; **Multiple Access Techniques:** Frequency division multiple access, time division multiple access, code division multiple access, practical demand access systems, random access, multiple access with on-board processing; **Satellite Earth Solution Techniques:** Earth solution design, tracking, small earth station antennas, Equipment for the Earth station.

Essential Reading:

1. T. Pratt and W. Boston, ***Satellite Communications,*** John Wiley & Sons, 2004
2. William W Wu, ***Elements of Digital Satellite Communication, Vol. 1,*** Computer Science Press 2006.

Supplementary Reading:

1. T. T. Ha, ***Digital Satellite Communications,*** McGraw Hill, U. S. A., 2004
2. G. D. Gordon, W. L. Morgan, ***Principles of Communication Satellite,*** John Wiley & Sons, U. S. A., 2005

EC 419 COMPUTER COMMUNICATION NETWORKS 4 credits [3-1-0]

Communication Model, Data Communications, Computer Communication Architecture, Standard Making Organisations. Concepts and Terminology, Asynchronous and Synchronous Data Communications, Multiplexing Techniques. Communication Networking Techniques, Circuit Switching, Packet Switching, Local Area Networks. Protocols, Layered Approach, TCP / IP Protocol Suite, System Network Architecture. The Bridge and Routing, Connectionless internetworking, Connection oriented internetworking. Transport and Network Services TCP / UDP. Session Characteristics, OSI Session and Service Protocol. Presentation Concepts, Encryption and Authentication Codes, Virtual Terminal Protocols. Network Management, File Transfer and Electronic Mail. Communication Switching Techniques, Frame-mode Bearer Service, Frame Relay Congestion Control, Synchronous Transfer Mode.

Essential Reading

1. W. Stallings, ***Data and Computer Communications***, PHI, New Delhi, 2006

Supplementary Reading

1. A. S. Tanenbaum, ***Computer Networks***, 2^{nd} Ed.; PHI, New Delhi, 2002.
2. F. Halsall, ***Data Communications, Computer Networks and Open Systems***, Pearson Education, 2003

EC 421 DIGITAL VLSI DESIGN 4 credits [3-1-0]

Introduction to VLSI Design, Levels of abstraction and the complexity of design, Challenges of VLSI design: power, timing, area, noise, testability, reliability and yield; CAD tools: simulation, layout, synthesis, test; MOS modeling, MOS device models, Short-channel effects and velocity saturation, Scaling of MOS circuits; VLSI fabrication technology, Layout design, Design rules, Stick diagrams; The CMOS inverter, VTC, Switching behavior, Noise margins and power dissipation; Static and dynamic CMOS combinational logic gate, Transistor sizing in static CMOS, logical effort, Pass-transistor logic, sizing issues, Domino logic gates, estimating load capacitance, Simple delay models (RC) for CMOS gates, Power consumption; Latches and clocking, Flip-flops, Set-up and hold tests, Static and dynamic latch and flip-flop, Clock design; Datapath units, Adders, Shifters, Multipliers; Control logic strategies, PLAs, Multi-level logic, Synthesis and place-and-route CAD; MOS memories, Register, SRAM, DRAM; Global interconnect modeling, Capacitance, resistance and inductance of interconnect; Signal and power-supply integrity issues, Electromigration, RC interconnect modeling Driving large capacitive load, reducing RC delays; Layout design, Standard-cell layout, Chip layout and floor planning, Array layout; Implementation issues, Design for testability, Packaging technology, I/O issues: ESD protection, boundary scan, inductance, synchronization

Essential Reading

1. J. M. Rabaey, A. Chandrakasan and B. Nikolic, ***Digital Integrated Circuits: A DesignPerspective***, Second Edition, Pearson/PH, 2003. (Cheap Edition)

Supplementary Reading

1. J. P. Uyemura, ***Introduction to VLSI Circuits and Systems***, Wiley, 2001.
2. W. Wolf, ***Modern VLSI Design: Systems-on-Chip Design***, Third Edition, Pearson/PH, 2002. (Cheap Edition)
3. R. L. Geiger, P. E. Allen and N. R. Strader, ***VLSI Design Techniques for Analog and Digital Circuits***, McGraw-Hill, 1990.

Prerequisites: Must have taken EC 201, EC 202

EC 423	HDL AND HIGH LEVEL VLSI DESIGN	3 credits [3-1-0]

Prerequisites: EC 202: Digital Electronics

Basic concepts of hardware description languages., Hierarchy, Concurrency, logic and delay modeling, Structural, Data-flow and Behavioral styles of hardware description, Architecture of event driven simulators, Syntax and Semantics of VHDL, Variable and signal types, arrays and attributes, Operators, expressions and signal assignments, Entities, architecture specification and configurations, Component instantiation, Concurrent and sequential constructs, Use of Procedures and functions, Examples of design using VHDL., Synthesis of logic from hardware description.; CMOS Process and Masking Steps: Concept of Lambda, Design Rules, Layer Properties and Parasitic Estimation, Sheet Resistance, U Cg, Capacitance Ratio for Layers, Concept of tau, Quick estimation of delays. Design of Buffers and I/O Pads, CMOS Logic Design Styles and their Comparison, CMOS Logic Design Styles and their Comparison (Continued), From Specifications to Silicon, Abstraction Levels in VLSI Design.; Adder Architectures, Multiplier Architectures, Counter Architectures, ALU Architectures. Latches, Flip-flops, Registers and Register Files. PLA Design, Gate Array Approach, Standard Cell Approach. Moore and Mealy Machines, PLA-based Implementation, Random Logic Implementation, Micro-programmed Implementation (ROM-based Implementation) SRAM Cell, Different DRAM Cells, Arraying of Cells, Address Decoding, Read / Write Circuitry, Sense Amplifier Design, ROM Design. Clock Skew, Clock, Distribution and Routing, Clock Buffering, Clock Domains, Gated Clock, Clock Tree.

Essential Reading:

1. C. H. Roth, ***Digital Systems Design Using VHDL***, Thomson Publications, Fourth Edition, 2002
2. V. A. Pedroni, ***Circuit Design with VHDL***, MIT Press/PHI, 2004. (Cheap Edition)

Supplementary Reading:

1. Z. Navabi, ***Verilog Digital System Design***, Second Edition, Tata McGraw-Hill, 2008.
2. R. C. Cofer and B. F. Harding, ***Rapid System Prototyping with FPGAs: Acceleratingthe Design Process***, Elsevier/Newnes, 2005.

EC 424	EMBEDDED COMPUTING SYSTEMS	3 credits [3-1-0]

Microcomputer-based Systems, Software Development, Interfacing Methods, Interrupt Synchronization, Threads, Timing Generation and Measurements Serial I/O Devices, Parallel Port Interfaces, Memory Interfacing, High Speed I/O Interfacing Analog Interfacing Data Acquisition Systems, Microcomputer-based Control Systems Simple Networks, Digital Filters.; **Circuits and DSP Architectures:** Circuit design basics, deep submicron issues, low architectures for embedded systems.; **Architecture Design:** Embedded processor architectures, Architectural techniques for low power, Design methods for core based ASICs.; **Compiler and OS:** Introduction to compiler optimizations, Power models for compiler optimizations, Code size vs. performance / power trade offs.; **DSP Algorithm Design:** A/D conversion and finite precision analysis, Algorithms for embedded systems: source and channel processing, Portable embedded code.; **Networking:** Networking basics (addressing and routing), Wireless vs. wire-line networking, Distributed OS for networked embedded systems: Case study of JINI.;

Essential Reading:

1. W. Wolf, ***Computers as Components : Principles of Embedded Computer System Design***, Second Edition, Elsevier/MK, 2005
2. F. Vahid and T. Givargis, ***Embedded System Design: A Unified Hardware/SoftwareIntroduction***, Wiley, 2002.

Supplementary Reading:

1. P. Marwedel, ***Embedded System Design***, Springer, 2006.
2. Proceedings of the IEEE (Special Issue on HW/SW Codesign), March, 1997.

EC 431	PC BASED INSTRUMENTATION	3 credits [3-0-0]

Pre-requisite: EC 100: Basic Electronics

Introduction, Signal-conditioning and op amp circuits, Sensors and actuators, Principles of data acquisition, Hardware organization of IBM PC, Interfacing to IBM PC, Plug-in data acquisition and control boards, Data acquisition using GPIB, Data acquisition using serial interfaces, Networked data acquisition, Recent developments.

Essential Readings:

1. N. Mathivanan, ***PC-based Instrumentation: Concepts and Practice,*** PHI, 2008.

EC 432	BIOMEDICAL INSTRUMENTATION	3 credits [3-0-0]

Pre-requisite: EC 336: Industrial Instrumentation

INTRODUCTION TO BIOMEDICAL INSTRUMENTATION: Biometrics, Introduction to the man-instrument system, Components of the man-instrument system, Problems encountered in measuring a living system; BIO-ELECTRIC SIGNALS AND ELECTRONICS: Origin of bio-electric signals, Bioelectric potentials, Biopotential electrodes; PHYSIOLOGICAL TRANSDUCERS: Pressure transducers, Transducers for body temperature measurement, Pulse sensors, Respiration sensors; BIOMEDICAL RECORDERS: Electrocardiograph, Phonocardiograph, Electroencephalograph, Electromyograph; PATIENT MONITORING SYSTEM: System concepts, Measurement of heart rate, Blood pressure measurement, Measurement of temperature, Measurement of respiration rate, Apnoea detectors; BLOOD FLOW METERS: Electromagnetic blood flow meter, Ultrasonic blood flow meter, NMR blood flow meter, Laser Doppler flow meter; BLOOD GAS ANALYZERS: Blood pH Measurement, Blood PCO_2 measurement; BLOOD CELL COUNTERS: Method of cell counting, Coulter counters, Automatic recognition and differential counting of cells; RECENT DEVELOPMENTS.

Essential Readings:

1. L. Cromwell, F. J. Weibell, E. A. Pfeiffer, ***Biomedical Instrumentation and Measurements,*** Pearson Education, Delhi, 2005.
2. R. S. Khandpur, ***Handbook of Biomedical Instrumentation,*** Tata Mc Graw Hill, New Delhi, 2000.

Supplementary Readings:

1. J. G. Webster, ***Bioinstrumentation,*** Wiley Student Edition, 2004.
2. W. J. Tompkins, ***Biomedical Digital Signal Processing***, PHI India Pvt. Ltd., 2008.

EC 433	PROCESS CONTROL INSTRUMENTATION	3 credits [3-0-0]

Pre-requisite: EC 331: Control System Engineering

INTRODUCTION TO PROCESS CONTROL: A Process Control System, Important terms and the objectives of Automatic Process Control, Transmission Signals, Control Strategies; MATHEMATICAL TOOLS: Deviation variables, Linearization of functions of one variable, Linearization of functions of two or more variables; FIRST-ORDER DYNAMIC SYSTEM: Thermal Process, Gas process, Dead time, Level process, Response of first-order processes; HIGHER-ORDER DYNAMIC SYSTEMS: Tanks in series – Noninteracting systems, Interacting systems, Thermal process, Response of higher order systems; BASIC COMPONENTS OF CONTROL SYSTEM: Sensors and Transmitter, Control Valves, Feedback controllers (P, PI, PID); DESIGN OF SINGLE-LOOP FEEDBACK CONTROL SYSTEMS: Feedback control loop, Stability of the control loop, Tuning of feedback controllers, Synthesis of feedback controllers.

Essential Reading:

1. C. A. Smith & A. B. Compio, ***Principles and Practice of Automatic Process Control,*** John Wiley, 2004.

Supplementary Readings:

1. D. E. Seborg, T. F. Edgar and D. A. Mellichamp, ***Process Dynamics and Control***, John Wiley and Sons, 2004.
2. W. L. Luyben and M. L. Luyben, ***Essentials of Process Control***, McGraw-Hill International Edition, 2002.

EC 434	ANALYTICAL INSTRUMENTATION	3 credits [3-0-0]

Pre-requisite: EC 334: Instrumentation Devices

Statistical techniques: -Error analysis, distribution, confidence level, least square fitting, testing of hypothesis. Measurement of viscosity, humidity and thermal conductivity. Mass Spectroscopy. Gas Chromatography: - Principles and construction, detectors, Industrial gas chromatograph, Liquid chromatography. Ionising electrodes: -pH and ion sensitive electrodes, ISFET and chemical sensors. Absorption spectroscopy: -IR and UV spectroscopy. Non-dispersive technique of measurement; UV fluorescence spectroscopy. Emission Spectroscopy: Flame and atomic emission spectroscopy. X-ray methods of measurement: sources and detectors, X-ray absorption and florescence techniques. Chemical analysis of surface- Ion scattering spectroscopy, Auger Emission spectroscopy, ESCA. Nuclear Magnetic resonance Spectroscopy: Basic principle and its application. Environment and Pollution monitoring Instruments; Recent developments.

Essential Readings:

1. H. W. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, ***Instrument Method of Analysis,*** East West Publishers, 2002.
2. C. Wiston, ***X-ray Methods,*** John Wiley and Sons, 2000.

Supplementary Readings:

1. D. A. Strong, F. J. Holler, T. A. Nieman, ***Principles of Instrumental Analysis,*** Saunders, 2003.

EC 437	RADAR ENGINEERING	3 credits [3-0-0]

Introduction: Principle of detection and ranging, Radar frequencies and bands. Applications, Radar block diagram and operation.; Radar Range Equation: Range prediction, Minimum detectable signal, Receiver noise SNR, Noise temperature, Pattern propagation factor, Antenna gain, Loss factors, Jamming & Clutter, Accuracy of prediction. Integration of radar pulses, Radar cross section of targets, Transmitter Power, PRF and system losses & Propagation effects; Automatic Detection, Tracking and Sensor integration: Optimal detector, Target resolution, Automatic Tracking, Tracking while-scan system, Multi sensor integration, Maximum Likelihood Approach; CW FM Radar: Doppler Effect, CW Radar, Frequency-modulated CW Radar, Multiple-frequency CW Radar.; MTI and Pulse Doppler Radar: MTI delay lines, Delay line cancellers, Coherent and Non-Coherent MTI, Pulse Doppler Radar, Electronic Scanning Radar: Principle of Electronic Scanning by Phase, Frequency and switching Techniques, Linear array and beam steering, Planar arrays and Beam steering, Basic description of phased array Radar system, Generalized performance of a phase antenna system; Pulse Compression Technique: Pulse compression system, Linear FM, Non linear FM, Digital Pulse compression, Phase coded Waveforms, Optimal Binary Sequence. Time-frequency, Coded waveforms, Weighting & Equalization.

Essential Readings:

1. M. I. Skolnik, ***Radar Hand Book***, McGrawhill, 2008
2. Francois Le Chevalier, ***Principles of Radar and Sonar Signal Processing***, Artech House, 2002

Supplementary Readings:

1. M. I. Skolnik***, Introduction to Radar Systems***, McGraw Hill, 2004
2. G. Stimson, ***Introduction to Airborne Radar***, IEE Press, 2002

EC 442	ADVANCED TECHNIQUES IN DSP	4 credits [3-1-0]

Prerequisites: Digital signal Processing

Multi-rate Digital Signal Processing: Decimation by a factor D, interpolation by a factor 1, sampling rate conversion by a national factor I/D.; Sampling rate conversion of band pass signals.; Implementation of low pass filter and digital filter banks.; lattice filters, Linear prediction, forward and backward linear prediction, FIR wiener filter.; Power spectrum estimation, non-parametric method Barlett, Parametric method.; Yule-Walker MA and ARMA models. Higher order statistics and its applications.; DSP transforms: Discrete Hartely transform, Discrete consine transform, Discrete Wavelet transform, S-transform. DSP techniques for bioinformatics., recent topics

Essential Reading

1. J. G. Proakis, D. G. Manolakis, ***Digital Signal Processing,*** PHI, New Delhi, 1995.
2. S. J. Orfanidis, ***Optimum Signal Processing,*** Mac Millan Publishing Co., USA, 1985.

Suggested reading

1. C. K. Chui, ***An Introduction to Wavelets,*** Academic Press, USA, 1992.
2. Guoan Bi and Yonghong Zeng, ***Transforms and Fast Algorithms for signal analysis and representations,*** Springer, NY, USA, 2003
3. Lecturer notes

EC 443	DIGITAL IMAGE PROCESSING	3 credits [3-0-0]

Prerequisites: EC 341: Digital signal Processing

INTRODUCTION: Fundamental steps in digital image processing, Components of an image processing system, DIGITAL IMAGE FUNDAMENTALS: Image sampling and quantization, Some basic relationships between pixels, Linear and nonlinear operations, IMAGE ENHANCEMENT IN SPATIAL DOMAIN: Some basic gray level transformations, Histogram processing, Smoothing and Sharpening spatial filters, IMAGE ENHANCEMENT IN FREQUENCY DOMAIN: Smoothing and Sharpening frequency domain filters, Homomorphic filtering, IMAGE RESTORATION: Noise models, Restoration in the presence of noise only-spatial filtering, Estimating the degradation functions, Inverse filtering, COLOR IMAGE PROCESSING: Color models, Pseudo-color processing, IMAGE COMPRESSION: Image compression models, Loss-less and Lossy compression, MORPHOLOGICAL IMAGE PROCESSING: Dilation and erosion, Opening and closing, Some basic morphological algorithms, IMAGE SEGMENTATION: Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region based segmentation, RECENT DEVELOPMENTS**.**

Essential Reading:

1. R. C. Gonzalez and R. E. Woods, ***Digital Image Processing***, Pearson Education, 2006
2. L. R. Rabiner and R. W. Schafer, ***Digital Processing of Speech Signals***, Pearson Education, 2005

Supplementary Readings:

1. K. Jain, ***Fundamentals of Digital Image Processing***, Pearson Education, 2007
2. L. R. Rabiner and B. Gold, ***Theory and Application of Digital Signal Processing,*** Pearson Education, 2004

EC 444	SOFT COMPUTING	4 credits [3-1-0]

Fundamental Concepts: - Introduction to Artificial Neural Networks (ANN). Learning Process: - error–correction learning, Hebbian learning, competitive learning, Boltzmann learning, the credit-assignment problem, supervised learning, and other learning techniques. Single neuron/ Perceptron networks: - training methodology, typical application to linearly separable problems. Multilayer Perceptron: - Back propagation algorithm, virtues and limitation of BP algorithm, modifications to back-propagation. Radial-basis function Networks – interpolation problem, Covers theorem, regularization networks, applications. Recurrent Networks.; Introduction to Fuzzy systems, Membership function, Fuzzy relational operation, fuzzy IF THEN rules, Sugeno and Mamdani type systems, Adaptive Neuro-Fuzzy sytems, training methods Application of ANN and Fuzzy systems to non-stationary time series prediction; pattern classification; control; communication engineering; system identification and pattern classification.

Essential Reading:

1. S. Haykin, ***Neural Networks, A Comprehensive Foundation;*** Pearson Education, India (The book is also published by Prentice Hall of India), 2008 (ISBN- 81-203-2373-4).
2. M. T. Hagan, Howard B. Demuth, Mark H. Beale, ***Neural Network Design***; (ISBN: 0-9717321-0-8); Thomson 2002
3. Jang, Sun and Mizutani, ***Neuro-Fuzzy and Soft-Computing – A computational approach to learning and machine intelligence***; Prentice Hall of India; ISBN-81-203-2243-6

Supplementary Reading:

1. S. Kumar, ***Neural Networks: A Classroom approach***, Tata Mcgraw Hill, 2004, ISBN: 9780070482920

EC 446	ADAPTIVE SIGNAL PROCESSING	4 credits [3-1-0]

Prerequisites: Digital signal Processing

Adaptive systems: Examples and applications. Adaptive linear combiner : the performance function, gradient and minimum mean square error, alternative expression of gradient, LMS, NLMS, sign-error, sign-data and FXLMS algorithms, transform domain LMS, Recursive least square algorithm, windowed RLS, computational complexity, Block adaptive filter(time and DFT domains), adaptive lattice filters, IIR adaptive filter : equation error form. Adaptive filtering, adaptive channel equalization, Adaptive line enhancement and adaptive system identification. Hardware implementation of digital adaptive filter. Applications of adaptive filter : 50Hz interference in electrocardiography, cancellation of donor-heart interference, cancellation of maternal ECG in electrocardiography, cancellation noise in speech signals, adaptive echo cancellation in long distance telephone line, self tunning filter. Adaptive control systems : model inverse and model reference controls. Introduction of adaptive array and adaptive beam forming. Recent advances in adaptive filtering.

Essential readings

1. S. Haykin and T. Kailath, ***Adaptive Filter Theory,*** Pearson Education, 4th Edition, 2005.
2. B. Widrow and S. D. Sterns, ***Adaptive Signal Processing***, Pearson Education, 2nd Indian reprint, 2002.

Suggested reading

1. Lecturer notes

EC 448	EVOLUTIONARY COMPUTING	4 credits [3-1-0]

Genetic Algorithm: Basic concepts, Search space, working principle. Encoding : binary, Octal, Hexadecimal, permutation, Value and Tree. Decoding, fitness function, Selection : Roulette-wheel, Boltzmann, Tournament, Rank and Steady-state. Elitism, Crossover : single-pint, two-point, multi-point, uniform, matrix and cross over rate, Mutation : mutation, mutation rate. Variations of GA : Adaptive GA and Real coded GA.; Ant colony optimization : Ant foraging behaviour, combinatorial optimization, Routing in communication network, traveling sales man problem, graph portioning, nest building.; Particle swarm Optimization : basic principle, algorithm, flowchart. Variations of PSO : weighted, repulsive, stretched, comprehensive learning, combined effect PSO and clonal PSO.; Bacterial Foraging Optimization : Forging theory, social foraging, foraging behaviour of E. coli bacteria, BFO algorithm, chemotatic, swarming, reproduction and elimination and dispersal. Variations of BFO : fuzzy BFO and Adaptive BFO.; Artificial Immune System: overview, central and peripheral immune systems, immune network : clonal selection and its mathematical modeling, beyond clonal selection, danger theory, negative selection.; Applications : function optimization, adaptive system identification, channel equalization and financial forecasting.

Essential readings

1. D. E. Goldberg, ***Genetic Algorithms in search***, Optimization and machine learning, 1989.
2. Eric Bonabeau, M. Dorigo and G. Theraulaz, ***Swarm Intelligence : From natural to Artificial Systems***, **(Santa Fe Institute Studies in the Sciences of Complexity Proceedings)**, 1999.

Suggested Readings

1. R. C. Eberhart, Y. Sai and J. Kennedy, ***Swarm Intelligence, The Morgan Kaufmann Series in artificial Intelligence,*** 2001.
2. K. M. Passino, ***Biomimicry for optimization,*** control and automation, 2004.
3. D. Dasgupta, ***Artificial Immune Systems and their applications***, 1998.
4. Lecturer Notes

EC 471	OPTICAL COMMUNICATION LAB	2 credit [0-0-3]

End preparation of optical fiber. Core and cladding diameter measurement of Optical fiber; Investigate the propagation of light through an optical fiber. Calculate the light attenuation due to: Scattering and absorption; Fiber misalignments; Numerical aperture mismatch; Core area mismatch; To familiarize with the optical fiber Bi-directional couplers and wavelength division Mux-demux components and the measurements of its different parameters; Experimental studies on LED characteristics; Experimental studies on Photo detector characteristics; Experiment of coupling method between optical fiber and light source; Studies on Fiber-optic communication link design; Studies on adjustable optical attenuator and parameter measurement; Studies of microbend effect on signal propagation through an optical fiber; Fiber characterisation using OTDR.

EC 472	IMAGE PROCESSING LAB	2 credit [0-0-3]

Read, Load and Display some color and gray scale images; Perform Negative, Logarithmic and Power Law Transformation of different images; Find the histogram of the image. Develop histogram-equalization algorithm and display the histogram equalized image; Write the programs to perform filtering operation in spatial domain on noisy image corrupted with (i) Gaussian noise (ii) Salt and Pepper noise; Find Peak Signal to Noise Ratio (PSNR) in both cases; Write program for Ideal Low Pass, Butterworth Low Pass and Gaussian Low Pass filter in frequency domain for removing Gaussian noise from images; Write programs for Ideal High Pass, Butterworth High Pass and Gaussian High Pass filter in frequency domain for sharpening different test images; Develop compressed image using (i) Run Length Encoding (ii) Huffman Coding; Display compressed image. Find the compression ratio and bits/pixel; Perform segmentation on bi-level images using Histogram method; Segment an image using (i) Region Growing (ii) Region Merging (iii) Region Splitting; Write program for Erosion and Dilation; Perform the following Geometric Transformations on different images (i) Scaling (ii)Translation (iii) Shearing; Mini Project

EC 473 VHDL-LAB 2 credit [0-0-3]

Design a full adder using Dataflow modeling; Design a full adder using half-adder; Design a half adder; Design a 4-bit adder cum sub tractor using: (a) 4: 1 MUX using the following: (a)dataflow (b)using when else (c) structural modeling using 2: 1 MUX (d) behavioral modeling using (i)case statement (ii) if else statement (e)mixed style of modeling(use structural, behavioral, dataflow); Design a Decoder(3 : 8) and Encoder (Gray to Binary); Design a BCD to 7-Segment Decoder: Interface the 2-bit adder with 7-segment display; Design 4-bit Even/Odd parity checker & generator; Design of Flip-Flops: (a)S-R Flip Flop (b)J-K Flip Flop (c) D Flip Flop (d) T Flip Flop; Design of counters: 4 bit up counter(use asynchronous reset) (b)4 bit down counter(use synchronous reset) (c) 4-bit up/down counter (d) Decade counter.; Design of Shift-Register: (a) Serial-in serial-out (b)Serial-in parallel-out; Design the following using Generic (a)Generic Decoder (b)Generic parity (c) detector; Generic parity generator; Microcomputer programming. design programs for microcontrollers in assembly language, with the use of different addressing modes, subroutines and stack operations, and interrupts; Examples: Hexadecimal addition of two numbers; Splitting a byte into nibbles; Hexadecimal multiplication of two numbers; Display letter 'A' on dot matrix display; Check the number for being odd or even.

EC 474 DSP PROCESSOR LAB 2 credit [0-0-3]

Familiarization with Texas instruments based DSP processors; Familiarization with Analog Devices based DSP processors; Practice on processors language; Implementation of various transforms and their inverses : DFT, FFT, DCT, DHT and DWT; Implementation of circular convolution and correlation in time and DFT domains; Implementation of overlap-save based linear convolution in time and DFT domains; Implementation of low pass and high pass FIR filter using windowing technique; Implementation of bilinear transformation based IIR filter; System Identification using LMS based tap-delay adaptive filter; Channel equalization of linear and nonlinear channels using LMS technique; Recovery of fundamental frequency from a mixture of signal and noise

EC 475 VLSI LAB 2 credit [0-0-3]

Study of PMOS & NMOS Characteristics using SPICE; Layout of Basic circuit elements NMOS, PMOS using L-Edit; Layout & Circuit Simulation of CMOS Inverter; Study the static behavior of CMOS inverter w. r. t. V_{DD} and Temperature; Study the Dynamic behavior of CMOS inverter w. r. t. $V_{DD,;}$ Simulation of basic gates; Simulation of Combinational and Sequential circuits; Layout experiments of devices and inverter; Layout of Combinational Circuits; Layout of Sequential Circuits

EC 476 BIOMEDICAL LABORATORY 2 credit [0-0-3]

Study and recording of Electrocardiograph; Study and recording of Electroencephalograph; Study and recording of Electromyograph; Design of pulse sensor; Design of respiration sensor; Blood pH measurement; Measurement of blood $pCO_{2;}$ Study on photoplethysmography and its use for heart beat counting.

EC 477 MOBILE COMMUICATION LAB 2 credit [0-0-3]

Generation of baseband signal for GSM, CDMA, Bluetooth, WLAN and WiMAX. Estimation of the signal spectrum at baseband; Analyze the working of the RF section of a mobile cellular receiver; Signal generation, reception and analysis of Bluetooth signal using random number as information bits; Simulate the working of codec in a GSM receiver using MATLAB and Labview; Analyze propagation characteristics of GSM, IS95, CDMA2000 using Qualnet simulator; Determine the mobile channel transfer function using vector network analyzer, signal generator and spectrum analyzer; Test an error correction coding scheme using software defined radio system; Design equalizer for GSM receiver on a software defined radio system; Design a mobile CDMA receiver using software defined radio set.

EC 479 PROCESS CONTROL LABORATORY 2 credits [0-0-3]

To study the characteristics of P/I & I/P converter; Determination of the different types of valve characteristics & calculate the gain at various condition; Study and synthesis of Hydraulic & Pneumatic systems using Trainers; Experiments on Air velocity sensor and its associate signal conditioner circuit; Performance analysis on ON-OFF/P/PI/PD/PID controllers on Co-Current and Counter Current Heat Exchanger Process; Phase- Plane analysis on Relay Control system; Study of Linear System Simulator; Study of Compensation Design Network.

DEPARTMENT OF ELECTRICAL ENGINEERING

DETAILED SYLLABI OF COURSES

Sub. Code.	Subject	L-T-P	Credits
EE 101	Basic Electrical Technology	3-1-0	4
EE 203	Electrical Machines – I	3-1-0	4
EE 204	Electro Magnetic Fields	3-1-0	4
EE 208	Electrical Technology & Applications	3-0-0	3
EE 209	Network Analysis	3-0-0	3
EE 240	Measurement and Instrumentation	3-1-0	4
EE 241	Network Theory	3-1-0	4
EE 242	Digital Electronics and Microprocessor	3-1-0	4
EE 243	Analog Electronics	3-1-0	4
EE 244	Signals & Systems	3-1-0	4
EE 270	Basic Electrical Engineering Laboratory	0-0-3	2
EE 271	Network Laboratory	0-0-3	2
EE 272	Measurement Laboratory	0-0-3	2
EE 274	Electronics Laboratory	0-0-3	2
EE 277	Electrical Machines Laboratory – I	0-0-3	2
EE 301	Electrical Machines – II	3-1-0	4
EE 306	Electromagnetic Fields	3-0-0	3
EE 308	Utilization of Electrical Energy	3-0-0	3
EE 309	Power Generation Systems	3-0-0	3
EE 311	Transmission and Distribution of Electric Power	3-1-0	4
EE 312	Switch Gear & Protective Devices	3-1-0	4
EE 322	Control System – I	3-1-0	4
EE 324	Power Electronics	3-1-0	4
EE 336	Advanced Instrumentation	3-0-0	3
EE 341	Embedded Systems	3-0-0	3
EE 345	Communication Systems Principles	3-0-0	3
EE 355	Computer Organization & Operating Systems	3-0-0	3
EE 356	Digital Signal Processing	3-0-0	3
EE 370	Power Electronics Laboratory	0-0-3	2
EE 371	Communication System Laboratory	0-0-3	2
EE 372	Control System Laboratory	0-0-3	2
EE 373	Electrical Machines Laboratory – II	0-0-3	2
EE 374	Electrical Systems Simulation Laboratory	0-0-3	2
EE 375	Embedded Systems Laboratory	0-0-3	2
EE 376	Power Systems Laboratory	0-0-3	2
EE 377	Electrical Machine Design	0-0-3	2
EE 391	Special Topic in Electrical Engineering – I		3/4
EE 392	Special Topic in Electrical Engineering – II		3/4
EE 393	Special Laboratory in Electrical Engineering – I	0-0-3	2

EE 394	Special Laboratory in Electrical Engineering – II	0-0-3	2
EE 395	Engineering Product Development Project – I	0-0-6	4
EE 396	Engineering Product Development Project – II	0-0-6	4
EE 401	Power System Operation and Control	3-1-0	4
EE 404	Renewable Energy Systems	3-0-0	3
EE 405	Utilization of Electrical Energy & Drives	3-1-0	4
EE 406	High Voltage DC Transmission	3-0-0	3
EE 407	Electric Drives	3-1-0	4
EE 408	Electromagnetics Theory and Applications	3-0-0	3
EE 416	Power System Transients	3-0-0	3
EE 417	High Voltage Engineering	3-1-0	4
EE 425	Control System – II	3-1-0	4
EE 426	Fuzzy Modeling & Control	3-0-0	3
EE 427	Soft Computing	3-1-0	4
EE 428	Electrical Drives Concepts & Applications	3-0-0	3
EE 429	Advanced Control Theory	3-1-0	4
EE 436	Adaptive Control and System Identification	3-0-0	3
EE 438	Industrial Automation & Control	3-0-0	3
EE 445	Data Communication & Networks	3-1-0	4
EE 454	Digital Communication	3-0-0	3
EE 455	Digital Signal Processing	3-1-0	4
EE 456	Robotics and Computer Vision	3-0-0	3
EE 471	Electrical Drives Laboratory	0-0-3	2
EE 472	Control & Electrical System Design	0-0-3	2

For B. Tech Courses (3 or 4 level) please refer to the B. Tech Curriculum and Syllabi, for M. Tech Courses (6 level) please refer to M. Tech Curriculum and Syllabi.

EE 101 BASIC ELECTRICAL TECHNOLOGY 4 credits [3-1-0]

Introduction: Sources of energy, steam, hydro and nuclear power generation, general structure of electrical power systems. DC Networks: Kirchoff's laws, node voltage and mesh current methods, delta-star and star-delta conversions, superposition principle, Thevenin's and Norton's theorems. Single phase AC circuits: Single phase emf generation, average and effective values of sinusoids, solution of R, L, C series circuits, j operators, solution of parallel and series-parallel circuits. Three-phase AC circuits: Three phase emf generation, delta and star connections, line and phase quantities, solution of the three phase circuits with balanced voltage and balanced load conditions, phasor diagram, measurement of power in three phase circuits, three phase four wire circuits. Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. DC machine**:** Construction, emf and torque equations, DC motor starters, speed control of DC motors. Transformers: Construction, emf equation, phasor diagrams on lo load and full load, equivalent circuit, auto transformer. Induction motor: Construction, the revolving magnetic field, torque equation, slip, starters for squirrel cage and slip ring type induction motors. Electrical Measuring instruments: DC PMMC instruments, shunt and multipliers, moving iron ammeters and voltmeters, wattmeter, AC energy meter.

Essential Reading:

1. E. Hughes, ***Electrical Technology***, ELBS, 1997.

Supplementary Reading:

2. V. D. Toro, ***Basic Electrical Engineering***, PHI, 2000.

EE 203	ELECTRICAL MACHINES – I	4 credits [3-1-0]

DC Machines: Review of constructional features, armature winding, Lap and Wave winding. Review of EMF equation for a generator and Torque equation for a motor. Armature reaction, Distribution of Flux density in the air gap, commutation, Methods for improving commutation. DC Generator: Methods of excitation, open circuit characteristics, Load characteristics and voltage regulation. DC motor: Speed torque characteristics of motors, Regions of normal operations, Methods of speed control. Losses and Efficiency of DC machines: Swinburne's test & Hopkinson's test. Transformers: Review of emf equation and equivalent circuit, voltage regulation and efficiency, Determination of parameter from OC & SC tests, Back to Back test, parallel operation and load sharing, per-unit representation of transformer parameters & problem solving. Auto Transformer: Principle of operation, Phasor diagram, Equivalent circuit and comparison with two winding transformer. Three Phase Transformer: Construction of various types, operating characteristics of Star–Star, Star–Delta, Delta – star, Delta – Delta, Open – Delta and Zigzag connections, Vector Groups, Phase transformation, Three phase to Two phase, Three phase to Six phase, Three phase to Twelve phase transformation, Scott connection, parallel operation of Three phase transformer, Time harmonies in transformers – their cause and remedy, Three winding transformers equivalent circuit and applications.

Essential Reading:

1. A. E. Fitzagerald, C. M. Kingsley (Jr) and S. D. Umans, ***Electric Machinery,*** Tata McGraw Hill, 2003.

Supplementary Reading:

1. I. L. Kosow, ***Electric Machinery & Transformers***, PHI, 2001.
2. C. I. Hubert, ***Electric Machines***, Pearson Education, 2003.

EE 204	ELECTROMAGNETIC FIELDS	4credits [3-1-0]

Fundamentals of Field Theory, Maxwell's equations, Boundary conditions in Electromagnetic Field, Energy Theorems and Pointing Vector, Electromagnetic Wave Equation in Dielectrics and Conductors, Solution of Wave equation in Cartesian Coordinates in homogeneous Dissipative and Non dissipative Regions, Waves at interface between conductors and Dielectrics. Transmission Lines: Introduction, Line Transmission Theory, Variation of Voltage and Current at distance x from the sending end, Primary Line Constant, Phase Velocity and Line wavelength, Characteristics impedance, The Propagation Coefficient, Computation of Primary constants from values of short circuit and open circuit impedances, Phase and Group velocities, Standing Waves, Lossless Lines at Radio Frequencies, Voltage Standing Wave Ratio, Reflection Coefficient, Transmission Lines as Circuit Elements, Smith Chart, Solution of problems using Smith Chart, Stub Matching. Wave Guides: Introduction, Physical Mechanism of Wave Guide Propagation, Phase and Group Velocities, Rectangular Wave Guides, Cut off in a Rectangular Wave Guide, Wave Guide dimension, Wave Guide Impedance. Antennas: Introduction, Antenna Equivalent Circuits, Coordinate System, Radiation Fields, Polarization, The Isotropic Radiator, Power Gain of an Antenna, Effective Area of an Antenna, The Hertzian Dipole, Half Wave Dipole, Vertical Antennas, Folded Elements, Non-Resonant Antennas, Driven Arrays, Parasitic Arrays.

Essential Reading:

1. M. N. O. Sadiku, ***Elements of Electromagnetics***, Oxford University Press, 2002.
2. W. H. Hayt, ***Engineering Electromagnetics***, TMH, 1992.

Supplementary Reading:

1. D. K. Cheng, ***Field and Wave Electromagnetics***, Pearson Education, 2003.

EE 208	ELECTRICAL TECHNOLOGY & APPLICATIONS	3 credits [3-0-0]

Transformer: Three phase transformer connections, Testing, Phase conversion, Autotransformer and Induction Regulator. D. C Machines: Construction, Basic EMF and torque equations, classification. Voltage builds up in D. C generators, performance characteristics; D. C motors torque /speed characteristics, speed control and braking, Testing and efficiency. Induction machines: Constructional features and rotating magnetic field. Circuit model and phasor diagram. Torque-slip characteristics pull-out torque, Operating performances, Circle diagram, Testing, starting and speed control and Braking. Single phase induction motors – classification, Universal motors, Utility. Synchronous machines: Constructional features, synchronous generators and motors, equivalent circuit and phasor diagram, power and torque characteristics, hunting, starting of synchronous motors; Salient pole synchronous machine - phasor diagram and determination of synchronous reactance, Voltage regulation of alternators, parallel operations, Utility.

Essential reading:

1. A. E. Fitzagerald, C. M. Kingsley (Jr) and Umans, ***Electric Machinery,*** Tata McGraw Hill, 2003.

Supplementary reading:

1. I. L. Kosow, ***Electric Machinery & Transformers***, PHI, 2001.

EE 209 NETWORK ANALYSIS 3 credits [3-0-0]

AC Circuits: Review of series and parallel AC circuits in the context of super node and super mesh. Series and Parallel Resonance in AC Circuits: Characteristics, properties of resonance circuits, Selectivity, Bandwidth and Quality Factor. Coupled Circuits: Coefficient of coupling, Dot convention, Analysis of coupled circuits. Opamp Circuit: Solution of opamp circuits under the assumption of ideal conditions using network concepts. Network Theorems: Thevenin's, Norton's and Superposition theorems applied to circuits containing dependent sources. Three-phase Circuits: Analysis of three phase unbalanced circuits for 3-wire and 4-wire systems. Transients in Electric circuits: DC and AC transients in R-L, R-C and R-L-C circuits using Laplace Transform. Complex Waves: RMS value of complex waves circuit response to non-sinusoidal excitations. Two-port Networks: Two-port network concept, Representation in T and PI Configuration, Z, Y, h and ABCD parameters, image impedances, Interconnection of Two-port networks. Network Functions: Natural frequency of a network variable and a network, Network functions with examples and general properties, concept of complex frequency, poles, zeros and frequency response.

Essential Reading:

1. W. H. Hayt and T. E. Kimmerley, ***Engineering Circuit Analysis***, TMH, 2001.

Supplementary Reading:

1. M. E. Van Valkenberg, ***Network analysis***, PHI, 1990.

EE 240 MEASUREMENT AND ELECTRONICINSTRUMENTATION 4 credits [3-1-0]

Measurement of Electrical Quantities Standards of Measurement & Errors, Voltmeter, Ammeter, Multimeter Wattmeter and Energy meter. **Measurement of Electrical Elements :** Measurement of low, medium and high resistances, insulation resistance measurement AC bridges for inductance and capacitance measurement. **Instrument Transformers** Current and Potential transformers, ratio and phase angle errors. **Electronic Measurements:** Electronic voltmeter, multimeter, wattmeter & energy meter. Time, Frequency and phase angle measurements using CRO; Spectrum & Wave analyzer.; Digital counter, frequency meter, voltmeter, multimeter and storage oscilloscope.; **Instrumentation:** Transducers, classification & selection of transducers, strain gauges, inductive & capacitive transducers, piezoelectric and Hall-effect transducers, thermisters, thermocouples, photo-diodes & photo-transistors, encoder type digital transducers, Signal conditioning and telemetry, basic concepts of smart sensors and applications. Data Acquisition Systems.

Essential Reading:

1. A. K. Sawhney, ***Electrical and Electronics Measurements and Instrumentation,*** DhanpatRai, 2003.
2. W. D. Cooper and A. P. Helpric, ***Modern Electronic Instrumentation & Measurement Techniques,*** PHI, 1990.

Supplementary Reading:

1. J. P. Bentley, Principles of Measurement Systems, Longman Group Ltd. (Pearson Education), 1995.
2. M. Tooley, ***PC Based Instrumentation and Control***, Newnes, 1997.
3. A. J. Bouvens, ***Digital Instrumentation,*** McGraw Hill, 1986.

EE 241 NETWORK THEORY 4 credits [3-1-0]

Review of Series and Parallel AC circuits in the context of supernodes and supermesh. Opamp circuits; Series and parallel resonance in AC circuits: Properties of resonant circuits, selectivity, bandwidth and quality factor.; Coupled circuits: Coefficient of coupling, dot convention, analysis of coupled circuits.; Network theorems: Thevenin's and Norton's (dependent sources A. C. circuits), Maximum power transfer theorem, solving circuit problems using source transform techniques.; Three phase systems: Review of balanced three phase systems, 3 wire and 4 wire systems, phase sequence, relation between line and phase quantities of star and delta systems, active and reactive power, solution of balanced three phase circuits, unbalanced three phase three wire and four wire systems, measurement of power in three phase balanced and unbalanced systems. Introduction to the concept of symmetrical components and its applications.; Transients in Electric circuits: D. C. and A. C. Transients in R-L, R-C and R-L-C circuits using Laplace Transform. Wave form synthesis using Laplace Transform techniques.; Complex waves: R. M. S. values of complex waves, circuit response to non-sinusoidal inputs.; Two Port Networks: Two-Port network parameters, T and PI section representation, open circuit and short circuit impedance in terms of A B C D constants, Image impedances, relationship between the image parameters and the short circuit and open circuit impedances, Symmetrical Networks.; Network Functions: Natural frequency of a network variable and a network, Network functions with examples and general properties, concept of complex frequency, poles, zeroes, and frequency response.

Essential Reading:

1. W. H. Hayt & J. E. Kemmerley, ***Engineering Circuit Analysis,*** TMH, 2001.

Supplementary Reading:

1. M. E. V. Valkenburg, ***Network Analysis,*** PHI, 1990.

EE 242	DIGITAL ELECTRONICS & MICROPROCESSOR	4 credits [3-1-0]

Introduction to Boolean algebra and Switching Function, Boolean minimization. Combinational Logic Design using MSI circuits : Full Adder / Subtractor, BCD Adder, LAC Adder, Decoder, MUX/DEMUX three structure, Combinational logic design using ROM array, Applications of MSI designs.; Integrated Circuits: Difference between combinational and sequential circuits, Flip Flops, Counters, Shift Registers and PLA.; Analysis and Synthesis of Sequential Circuits: Basic models of sequential M/C, Analysis of Asynchronous and Synchronous circuits, Synthesis of completely and incompletely specified synchronous sequential M/Cs.; Introduction to Microprocessor : Overview of architecture of Intel 8085 Microprocessor (Register, Stack, Interrupt) Instruction set and programming.; Introduction to 16 Bit Microprocessor : Architecture of 8086 CPU architecture, Internal operations, Machine Language instructions, Addressing mode, Instruction Format, Instruction executions, Addressing mode, Instruction Format, Instruction execution timing, comparison of 8088 with 8086. Assembly language programming and Instructions: Assembler instruction format, Data Transfer, Arithmetic, Branch, Flag manipulation, Logical, Shift and Rotate. String Manipulation Stack Manipulation, all and return instructions, REP Prefix, segment override prefix, and simple assembler directives such as real, variable, DB, DW, DD, EQU, END, Assume, pointer (byte, word, double word, Near, Short, and Far).

Essential Reading:

1. B. N Jain and R. P. Jain, ***Modern Digital Electronics***, Tata McGraw Hill, 2006.
2. B. B. Bray, ***The Intel Microprocessors- 8086/8088, 80186, 80286, 80386, and 80486-Architecture, Programming and Interfacing***, Prentice Hall, 2000.

Supplementary Reading:

1. D. V. Hall, ***Microprocessor and Interfacing programming & Hardware***, TMH, 2001.
2. A. K. Ray and K. M. Bhurchandi, ***Advanced Microprocessors & Peripherals: Architecture, Programming & Interfacing,*** TMH, 2008.

EE 243	ANALOG ELECTRONICS	4 credits [3-1-0]

FET: Types, Biasing of FET, MOSFET biasing, MOSFET as an amplifier, CMOS circuits, MOSFET as analog switch, Concept of MESFET. OPAMP: Parameters of OPAMP, open loop and closed loop configurations, Bandwidth with feedback, Linear OPAMP circuits and applications, Non linear OPAMP circuits and applications. Oscillators: Concept of feedback, Classification of oscillators, Barkhausen. s criterion, RC oscillator, Wien bridge oscillator, LC oscillator (Hartley and Colpitts), Crystal oscillator, Negative resistance, Device based oscillators. Wave shaping and Multivibrators circuits: clippers and Clamers, Astable, Monostable and BistableMultivibrators, Schmitt Trigger. Boolean algebra and Switching Function, Boolean minimization. Combinational Logic Design using MSI circuits : Full Adder / Subtractor, BCD Adder, LAC Adder, Decoder, MUX/DEMUX three structure, Combinational logic design using ROM array, Applications of MSI designs.; Integrated Circuits: Difference between combinational and sequential circuits, Flip Flops, Counters, Shift Registers and PLA.; Analysis and Synthesis of Sequential Circuits: Basic models of sequential M/C, Analysis of Asynchronous and Synchronous circuits, Synthesis of completely and incompletely specified synchronous sequential M/Cs

Essential Reading:

1. A. S. Sedra and K. C. Smith, ***Microelectronic circuits,*** Oxford University Press, 2005.
2. R. R. Spencer and M. S. Ghausi, ***Introduction to Electronic Circuit Design***, Pearson, 2003.
3. B. N Jain and R. P. Jain, ***Modern Digital Electronics***, Tata McGraw Hill, 2006.
4. B. B. Bray, ***The Intel Microprocessors- 8086/8088, 80186, 80286, 80386, and 80486-Architecture, Programming and Interfacing***, Prentice Hall, 2000

Supplementary Reading:

1. D. A. Bell, ***Electronic Devices and Circuits,*** Oxford University Press, 2008.
2. S. Salivahanan, N. S. Kumar and A. Vallavaraj, ***Electronic Devices and Circuits,*** TMH, 2008.
3. J. G. Graeme, G. E. Tobey and L. P. Huelsman, ***OPAMP: Design and applications,*** McGraw Hill, Digitized on Dec. 2007.

EE 244 SIGNALS & SYSTEMS 4 credits [3-1-0]

Mathematical Description of Signals: Continuous-Time Signal Functions, Discrete-Time Signal Functions, Signal Energy and Power.; Description and analysis of systems: System characteristics, Convolution sum, Convolution integral and their evaluation, analysis of LTI Systems based on convolution and differential equations.; Fourier series and Fourier Transform: Fourier series representation of Periodic Signals, Continuous and discrete time Fourier Transform, Fourier Transform Analysis of Signals and systems with examples.; Sampling and Discrete Fourier Transform: Representing a continuous-time signal by samples, Sampling Theorem, Aliasing, Sampling of Discrete time signals. Correlation, energy spectral density and power spectral density, Auto correlation, cross correlation, the ESD concept, and the PSD concept.; Transform domain considerations: The Laplace transform and its properties, Solutions of differential equations with initial conditions, The Z transform and its properties. Analysis and characterization of LTI systems using z transform.

Essential Reading:

1. C. L. Philips, J. M. Parr and E. A. Riskin, ***Signals, Systems and Transforms***, PHI, 2008.
2. A. V. Oppenhem, A. S. Willsky and I. T. Young, ***Signals and Systems,*** Prentice-Hall India, 1983**.**

Supplementary Reading:

1. M. J. Roberts, ***Signals and Systems,*** McGraw-Hill, 2004.

EE 271 NETWORK LABORATORY 2 credits [0-0-3]

DC analysis for R-L, R-C and R-L-C circuits; AC analysis for R-L, R-C and R-L-C circuits; DC circuit simulation for multiple branches consisting of dependent and independent sources; AC circuit simulation for multiple branches consisting of dependent and independent sources; Verification of Superposition theorem; Simulation of Half wave diode bridge rectifier circuit; Simulation of Full wave diode bridge rectifier circuit; Transistor circuit simulation with CE, CB and CC configuration; FET circuit simulation with CS and CD configuration; OPAMP circuit simulation; Series resonance circuit simulation; Parallel resonance circuit simulation.

EE 272 Measurement Laboratory 2 credits [0-0-3]

Verification of Thevenin's Theorem and Superposition Theorem; Voltage Current Relationship and locus diagram of a series R-L Circuit; Measurement of single phase power by 3 voltmeter method; Measurement of three phase power by two wattmeter method; Verification of Reciprocity and Maximum Power Transfer Theorem; Testing of single phase energy meter at different power factors; Study of series and parallel resonance; Determination of self and mutual inductance of a coupled circuit; Measurement of Iron losses by Lloyd Fisher's Square; Measurement of single phase power by 3 ammeter method; Localization of cable fault by Murray Loop method; Study of Schering and Anderson bridge

EE 274 Electronics LabORATORY 2 credits [0-0-3]

Study of Two Stage R. C. Coupled Amplifier: Single Stage Gain; Input and output Impedance; Frequency response; Study of Diode clipper circuit: Study of Basic OPAMP circuit; inverting; Non-Inverting; Voltage Follower; Scale changer; Summer; Differential Amplifier: Study of UJT static characteristic; Active filters using OP-AMP; Low pass Filter; Band pass filter; High pass filter; Band reject filter; Study of JFET characteristics; Study of negative feedback using Transistor; Study of Multi vibrator Circuit using IC555 timer; Study of Oscillator circuit: RC phase shift; Wein bridge; Parameter Measurement of OPAMP: Detector using OPAMP-741: Peak Detector; Zero Crossing Detector; Comparator; Window Detector; Study of MOSFET Characteristic; Study of basic logic gates and universal logic gates; Realization of logic circuits using universal logic gates; To construct and verify the operation of single digit and multi digit half adder, Full adder / subtracted using logic gates and IC 7483; To study the characteristics and operation of a programmable Shift Register using IC 7495; Verification of UP/ DOWN count using IC 74193. Study of Ring and Decade Johnson Ring counters using ICs and Flip- Flops. Comparison of Sequential and Combinational Logic Circuits; Study of Digital to Analog converter by weighted resistance method. Design and verification of A/D converter; Study of Seven Segment Display Technique using IC 7447/ 7446.

EE 277 electrical MachineS LabORATORY – I 2 credits [0-0-3]

Study of Electrical Motors & Starters; Measurement of armature & field resistances of a DC machine; Study of magnetization characteristic of separately excited DC generator; Speed control of DC motor by varying armature circuit and field circuit resistances; Hopkinson's Test of DC machine; Speed control of DC motor by Ward-Leonard method; Open circuit and short circuit test of single phase transformer; Back to back test on Single Phase Transformer; Parallel operation of single phase transformer; Determination of efficiency of DC machine by Swinburne's Test; Measurement of power using CT & PT; Load test of DC shunt motor.

EE 301	ELECTRICAL MACHINES - II	4 credits [3-1-0]

Synchronous Generator: Constructional Features of Salient Pole and Non-Salient Pole Machines, Arrangement of Field Winding in the two types of Machines. Cylindrical Rotor Theory: Phasor Diagram, Synchronous Reactance from O. C. and S. C. Characteristics, Load Characteristics, Z. P. F. Characteristics, Voltage Regulation by different methods, Power Angle Characteristics. Salient-Pole Theory: Blondel's Two-Reaction Concept, Direct Axis and Quadrature Axis Synchronous Reactance, Power Angle Characteristics, Slip Test. Parallel Operation. Synchronous Motor: Constructional features, Phasor Diagram, Torque and Power Relations in Non-Salient Pole and Salient Pole Motors, V-Curves, Various Types of Excitation, Synchronous Condenser, Methods of Starting, Applications. Three Phase Induction Motor: Constructional Features of Slip Ring and Squirrel Cage Type Motors, Principle of Operation, Flux and MMF Wave, No-Load Speed and Slip, Rotor Quantities Referred to Stator, Relationship Between Input Voltage and Current, Equivalent Circuit, Analysis of Equivalent Circuit, Torque Speed Characteristics, Starting, Maximum and Full Load Torque, Condition for Maximum Torque, Regions of Stable and Unstable Operations, Effect of rotor resistance and supply frequency on Speed Torque Characteristics, Losses, Efficiency, Performance Characteristics, The Circle Diagram, Starting of Slip Ring and Squirrel Cage Motors, High Starting Torque Motors. Speed Control: Various methods. Single phase induction motor: ; Constructional features, various types, Rotating magnetic field theory, Equivalent circuit, Determination of constants, methods of starting, Applications. Single Phase Series Motor: Construction, Principle of Operation, Phasor Diagram, Operation with AC and DC supplies, the universal Motor, Performance Characteristics, Effect of Compensation, Repulsion motor, Applications. Stepper Motor: Construction and Principle of Operation of Variable Reluctance Type and Permanent Magnet Type, Performance and Applications, Brushless D. C. Motors: constructional features, principle of operation, applications. Switched-Reluctance Motor: Constructional features, principle of operation and applications.

Essential Reading:

1. A. S. Langsdorf, ***Theory of A. C. Machines,*** TMH***, 2001.***
2. I. L. Kosow, ***Electric Machinery & Transformers***, PHI, 2001.

Supplementary Reading:

1. A. E. Fitzagerald, C. M. Kingsley (Jr) and S. D. Umans, ***Electric Machinery,*** Tata McGraw Hill, 2003.
2. C. I. Hubert, ***Electric Machines***, Pearson Education, 2003.

EE 306	ELECTROMAGNETIC FIELDS	3 credits [3-0-0]

Fundamentals of Field Theory, Maxwell's equations, Boundary conditions in Electromagnetic Field, Energy Theorems and Pointing Vector, Electromagnetic Wave Equation in Dielectrics and Conductors, Solution of Wave equation in Cartesian Coordinates in homogeneous Dissipative and Non dissipative Regions, Waves at interface between conductors and Dielectrics. Transmission Lines: Introduction, Line Transmission Theory, Variation of Voltage and Current at distance x from the sending end, Primary Line Constant, Phase Velocity and Line wavelength, Characteristics impedance, The Propagation Coefficient, Computation of Primary constants from values of short circuit and open circuit impedances, Phase and Group velocities, Standing Waves, Lossless Lines at Radio Frequencies, Voltage Standing Wave Ratio, Reflection Coefficient, Transmission Lines as Circuit Elements, Smith Chart, Solution of problems using Smith Chart, Stub Matching. Wave Guides: Introduction, Physical Mechanism of Wave Guide Propagation, Phase and Group Velocities, Rectangular Wave Guides, Cut off in a Rectangular Wave Guide, Wave Guide dimension, Wave Guide Impedance. Antennas: Introduction, Antenna Equivalent Circuits, Coordinate System, Radiation Fields, Polarization, The Isotropic Radiator, Power Gain of an Antenna, Effective Area of an Antenna, The Hertzian Dipole, Half Wave Dipole, Vertical Antennas, Folded Elements, Non-Resonant Antennas, Driven Arrays, Parasitic Arrays.

Essential Reading:

1. M. N. O. Sadiku, ***Elements of Electromagnetics***, Oxford University Press, 2002.
2. W. H. Hayt, ***Engineering Electromagnetics***, TMH, 1992.

Supplementary Reading:

1. D. K. Cheng, ***Field and Wave Electromagnetics***, Pearson Education, 2003.

EE 308	UTILIZATION OF ELECTRICAL ENERGY	3 credits [3-0-0]

ILLUMINATION: Production of light - lighting calculations - determination of MHCP and MSCP - Polar curves of different types of sources - Rousseau's construction - photometers - interior and exterior illumination systems - lighting schemes

- Design of lighting schemes - factory lighting - flood lighting - electric lamps - gaseous discharge lamps - high pressure and low pressure neon signs - high frequency, low pressure discharge tubes.; ELECTRIC FURNACES AND WELDING : Resistance, inductance and Arc Furnaces - Construction and fields of application - control equipment, high frequency dielectric heating, resistance - welding equipment - characteristics of carbon and metallic arc welding - butt welding - spot welding.; ELECTRO-CHEMICAL PROCESSES: Electrolysis – Electroplating – Electro deposition – Extraction of metals Current, Efficiency - Batteries – types – Charging Methods.; ELECTRIC TRACTION Railway electrification – definition and analysis of traction effort – speed – time curve – traction motors - battery driven vehicles - energy efficiency drives – advanced speed control measures- tractive effort calculations - electric braking - control wire - A. C. traction - recent trend in electric traction.; REFRIGERATION AND AIR-CONDITIONING Control of temperature - basic wiring diagram - simple heat load and motor calculations. Air-conditioning - function of complete air conditioning system - type of compressor motor and fan motor-wiring diagram for a typical air conditioning unit.

Essential Reading:

2. S. C. Tripathy, ***Electric Energy Utilisation and Conservation,*** Tata McGraw Hill, 1991.
3. W. F. Stocker and J. W. Jones, ***Refrigeration & Air Conditioning***, McGraw Hill, 1985.

Supplementary Reading:

1. C. L. Wadhwa, ***Generation, Distribution and Utilization of Electrical Energy,*** New Age, 1989.
2. N. V. Suryanarayana, ***Utilisation of Electric Power***, Wiley Eastern Ltd., 1993.
3. M. Prasad, ***Refrigeration and Air Conditioning***, Wiley Eastern Ltd., 1995

EE 309 POWER GENERATION SYSTEMS 3 credits [3-0-0]

Generation of electrical energy by conventional methods, Comparison of different sources of power. Nonconventional sources of energy. Thermal Power Plant: Line diagram of the plant. Boilers: working and classification. Super-heaters, Reheaters, economizers, air-heaters, draft system, feed water heaters and evaporators, cooling water supply and cooling towers. Speed governing and governors. Station auxiliaries. Generator cooling and exciters. Hydro Electric Generation: Classification of hydro plant, Selection of site, Estimation of power available, Selection of turbine and modeling of turbine. Plant layout, Governors and Hydro plant auxiliaries. Nuclear Power Generation: Principle of energy production by nuclear fission, schematic of nuclear power plant, nuclear fuels and fertile materials, nuclear reaction construction. Chain reaction, Moderator, coolants, control of fission, Reactor operation, different types of reactors, Problem of nuclear power plants. Economics of Power Generation: Cost of electrical energy, Methods of determining depreciation, straight line, diminishing value and sinking found method. Types of Tariffs influence of load and power factor on tariff, economics of power factor improvement.; Commissioning and Testing of Transformers and Alternators: Transformer connections, arrangement of transformer, commissioning and testing of transformers and alternators, supply system to station auxiliaries.

Essential Reading:

1. B. G. A. Skrotzki & W. A. Vopat, ***Power Station Engineering & Economy,*** McGraw Hill, Digitized on Dec 2007.

Supplementary Reading

1. M. M. El-Wakil, ***Power Plant Technology***, Mcgraw Hill, Digitized on Dec 2006.

EE 311 TRANSMISSION AND DISTRIBUTION OF ELECTRIC POWER 4 credits [3-1-0]

Power System Network: Basic structure of power system, Transmission voltages, Bundled conductors, Choice of economics voltages, Transmission of Network in India. Line Parameters: Line resistance, Inductance, Flux Linkages within the conductor producing the flux, Flux linkage outside the conductor producing the flux, Inductance of bundled conductor lines, capacitance of two wire line, Capacitance of three phase line with equilateral spacing, Capacitance of three phase line with Unsymmetrical spacing, Capacitance of bundled conductor of lines, Double circuit three phase lines. Performance of Transmission Lines : Representation of lines, Per unit method, Short transmission line, Medium length transmission line, Long transmission line, Evaluation of ABCD parameters, Equivalent and T circuits, Application of Matrix methods, Line voltage regulation and compensation, Regulating transformer. Overhead Line Insulators: Insulator materials, Types of insulators, voltage distribution over insulator string, Improvement of string efficiency, Insulator failure, testing of insulators. Mechanical Design of Overhead Lines: General consideration, Line supports, Span conductor configuration, spacing and clearances, sag and tension calculations, Conductor vibration. Corona: The phenomenon of corona, Corona loss, Factors and conditions affecting coronal loss, Coronal in bundled conductor lines. Interference between Power and Communication Lines: Electromagnetic Induction, Electro Static induction, Reduction of interference. Underground Cables: Classification of cables, Pressurized cables, Effective conductor register, conductor inductive reactance, parameters of single core cables, Capacitance of three core belted cable. Power System Transients : Circuit closing transient, Sudden symmetrical short circuit of alternator, Recovery transient due to removal of short circuit, Travelling waves on transmission lines, Wave equations, Arcing grounds, Line design based on direct strokes, Surge arrestors Insulation coordination. Extra High Voltage Transmission: Need for EHV transmission, Use of bundled conductors, Radio noise from EHV lines, Shunt compensation static-var systems, Series compensation, EHV systems in India. Distribution: Comparison of various distribution systems, voltage drop in distribution, Kelvin's Law, General design consideration, Load estimation. Design of Transmission Lines: Choice of voltage, Selection of conductor size, Choice of span, number of circuit, conductor, configuration. Power System Earthing.

Essential Reading:

1. C. L. Wadhwa, ***Electrical Power Systems,*** New Age, 2005.

Supplementary Reading:

1. L. M. Faulkenberry and W. Coffer, ***Electrical Power Distribution and Transmission***, PHI, 1996.
2. W. D. Stevenson, ***Elements of Power System analysis***, McGraw Hill, 1982.

EE 312	SWITCH GEAR AND PROTECTIVE DEVICES	4 credits [3-1-0]

Requirement of circuit breakers, characteristics of electric arc, principle of A. C. and D. C. arc interruption, recovery and restriking voltages and effect of current asymmetry upon them, Interruption of capacitive currents, current chopping circuit breaker ratings. Circuit Breakers: Types of A. C. and D. C. circuit breakers in general. Oil Circuit breakers: Plain break and controlled break O. C. B. Minimum oil circuit breaker, Air blast circuit breakers of different type. Vacuum and Sulphur hexafluoride circuit breakers. Fuses: H. R. C. Fuse, Construction, Capacity and characteristics Arrangements of circuit breaker, isolators, arrangement of bus bars, Limiting reactors in power system, Calculation of fault MVA for symmetrical short circuits and determination of C. B. capacity. Protective Devices: Philosophy of protection, Methods of earthing and their effect on fault conditions. Different types of relays: attracted armature type, balanced beam type, induction type. Static relays: Generalised theory of phase and magnitude, comparator, realization of different relay characteristics of static devices, Feeder protection: Time graded over current and earth fault system, Directional relays and their connection. Calculation of graded time settings. Distance relaying; Distance, impedance reactance and mho-relays, Arrangement of relay contacts. Pilot wire protection system: Circulating current system Balanced beam type opposed voltage system – Merz price and translay system, Protection of split core and parallel feeders, carrier current protection.; Power transformer protection: Differential protection and magnetic balance protection, restricted earth fault protection, Buchholz relay, protection of combined alternator and transformer.; Bus bar protection: Frame leakage scheme, Translay scheme, circulating current scheme introduction to protection against surges.; Testing of relays: Primary and secondary injection, Method of testing a simple overcurrent relay and E. F. relay.

Essential Reading:

1. J. L. Blackburn and T. J. Domin, ***Protective Relaying: Principles & Applications***, CRC Press, 2006.
2. B. Ravindranath and M. Chander, ***Power System Protection and Switchgear***, New Age, 1988.

Supplementary Reading:

1. S. S. Rao, Switch ***gear and protection,*** Khanna publishers, 1997.
2. T. S. Madhava Rao, ***Power system protection: Static Relays,*** Tata McGraw Hill, 1989

EE 322	CONTROL SYSTEM – I	4 credits [3-1-0]

Introduction to Automatic Control: Concept of control system, Definition, Open Loop/Closed-loop, Basic elements of a servo mechanism, Types of servomechanism, Development of Automatic Control.; Mathematical Model: Mathematical representation of physical system, Electrical mechanical systems, liquid level system, Transfer function and impulse response of linear systems, Block diagram, signal flow graphs, Application of the signal flow graphs for gain formula to block diagrams. Mathematical modeling of dynamical systems.; General Feedback Theory: Feedback, effect of feedback, Mathematical definition of feedback.; Control System Components: Potentiometer, Synchros, A. C. Servo motors D. C. and A. C. tacho generator, Example of closed loop systems using D. C. & A. C. Servomotors, Synchros, Tacho generators; Hydraulic Systems & Pneumatic Systems; Pump controlled and valve controlled Hydraulic motor & Actuators, Hydraulic valve, Hydraulic controllers and Pneumatic controllers.; Time Response of feedback control systems: Typical test signal for the transient analysis, time domain performance characteristics of feedback control systems, transient response, transient response of 2^{nd} order systems, transient response of a positional servomechanism, effects of derivative and integral controls on the transient performance, PI, PD, PID controllers, Tachometer feedback, Steady state response steady state error, The generalized error analysis, Stability linear control system: Routh-Hurwitz criterion. Frequency response method polar plots, Bodes plot, Magnitude versus phase shift plot frequency response of feedback control system, Frequency domain specifications, MP and WP for a second order system.; The Nyquist criterion and stability : ; Introduction, The Principle of argument the Nyquist path, Nyquist criterion and the GH Plot, The application of the Nyquist criterion, The effects of additional poles and zeros of G(s) H(s) on the shape of the Nyquist locus, Relative stability, gain margin, Phase margin, conditionally stable systems. The Root Locus Technique: Introduction to Root Locus, construction of the root loci, some other properties of the root locus, root locus of conditional stable systems.; Compensator Design: Lag/Lead/Lag-Lead Compensator Design using Root Locus & Bode Plot Methods; State variable analysis : ; Introduction, Concept of state, state variable and state model, State equations of continuous data control system, Derivation of state Model from transfer functions and Vice versa. Diagonalisation, Solution of state equation.

Essential Reading:

1. K. Ogata, ***Modern Control Engineering***, Pearson, 2003.
2. I. J. Nagrath, and M. Gopal, ***Control System Engineering***, New Age, 2002

Supplementary Reading:

1. M. Gopal, ***Control Systems: Principles and Design***, TMH, 2008.
2. B. C. Kuo, ***Automatic Control System***, Prentice Hall, Digitized Dec 5, 2007

EE 324	POWER ELECTRONICS	4 credits [3-1-0]

Power Semiconductor Devices: Control characteristics of Power Semiconductor Devices, Types of Power Electronic Circuits. Power Semiconductor Diodes: Types, Characteristics, Reverse Recovery Characteristics, Forward and Reverse Recovery Time, Series and Parallel Connection. Thyristors: Characteristics, 2-Transistor Model, Turn on and Turn off, dv / dt and di / dt protection, Thyristor firing circuits, UJT, Gate Turn-off Thyristors (GTO), Triac, FET controlled Thyristor, MOS controlled Thyristors. Series and Parallel operation of Thyristors. Line Frequency Phase Controlled Rectifiers and Inverters: Principle of Phase Control, Gate Trigger Controller Circuit. Single Phase Converter, Ideal Circuit with no source inductance and constant output d. c. current. Semi Converters and Full converter, Dual converter. Wave form and performance calculation, Effect of finite source inductance, Inverter Mode Operation. Three Phase Converter : Ideal Circuit without source inductance with constant output d. c. current, Three Phase Full Converters, Wave form Performance, Input Line Currents, Effect of Source Inductance and Commutation, Inverter mode of operation, A. C. Voltage Waveform. A. C. Voltage Controller: On-off control, Phase Control, R-Load, R-L Load, Cycloconverters Principles. Power Transistors: BJT Switching Characteristics and Switching limits base drive control Power MOSFET, Switching characteristics and gate drive, IGBT and STT, Isolation of gate base drive. DC-DC Switch Mode Converters (Choppers) : Principles of step-down chopper, step down chopper with R-L load, Principle of step-up operation, control of DC-Dc converter by PWM, Switching mode regulator, Step down (Back) Converter, Step-up (Boost) converter in Continuous Conduction mode. Thyristor Commutation Technique: Self Commutation, Impulse Commutation, Complementary Commutation. The Impulse Commutated Chopper. Pulse Width Modulated Inverters : Single phase half bridge and full bridge inverter, 3-phase inverter-180 degree and 120 degree conduction mode, Pulse Width Modulated Switching scheme for voltage control, SPWM and modified SPWM of 1-phase inverters, PWM with unipolar and Bipolar Voltage Switching, PWM in 3-phase VSI, Square wave operation, Switching Utilisation. Harmonic reduction by programmed harmonic elimination switching, Forced Commutated Thyristor Inverters, Auxiliary Commutated (Mc-Murray) Inverter, Complementary Commutated (Mc-Murray-Bedford) inverter. Current Source Inverter, Single phase CSI Inverter Circuit Design.

Essential Reading:

1. M. H. Rashid, ***Power Electronics-Devices, Circuits and Application,*** Prentice Hall of India, 2003.

Supplementary Reading:

1. N. Mohan, T. M. Undeland and W. P. Robbies, ***Power Electronics, Converters, Applications and Design,*** John Wiley and Sons, 2003.

EE 336	ADVANCED INSTRUMENTATION	3 credits [3-0-0]

Sensors: Types of sensors, their parameters. Microelectronic and microelectromechanic systems. Primary sensing principles and measurement variables, Sensor performance characteristics and terminology, Instrumentation-Transducer measurement circuits, Signal conditioning circuits, Sensor data acquirement. Basic principles of the acquirement and transmission of the data; Bio-medical Instrumentation; Selection of Transducers and Electrodes, Transmission and reception aspects of Bio-Medical signals Intelligent Sensor Systems- Intelligent pressure, Flow, Level, Temperature Sensors, Intelligent sensor application in process control, Complex sensors, biometric sensors, Intelligent analytical instruments, Application of intelligent sensor in biomedical engineering; Future scope of intelligent instruments- Structure, definitions and concepts, Smart sensors, Case study: the "electronic nose", The future of intelligent sensor systems- Multimodal sensors for target recognition, subject tracking, and event understanding. Real World Interfacing – LCD, ADC, Sensors, Stepper motor, keyboard and DAC, USB interfacing, Memory interfacing, Synchronous serial communication interfacing

Essential Reading:

1. I. R. Sinclair, ***Sensors and Transducers***, John Wiley & Sons, 2001

Supplementary Reading:

1. J. R. Brauer, ***Magnetic Actuators and Sensors***, Wiley-IEEE Press, 2006.

EE 341 EMBEDDED SYSTEMS 3 credits [3-0-0]

Architecture of 8086 CPU architecture, Internal operations, Machine Language instructions, Addressing modes, Instruction Format, Assembly language programming and Instructions, Data Transfer, Interfacing of peripherals.; 8051 Microcontroller Architecture: Function and basic description of 8051components to include Special Function Registers (SFRs). Interfacing and address decoding techniques. Essential hardware for computer control, Interfacing, address decoding, analogue and digital input/output. Input/output control A/D and D/A conversion, Interrupts, bus timing, serial and parallel communications. Bus timing, Interrupts Real-time systems. ***Software:*** Program creation, flow charting. Algorithms for embedded control. Structured programming, Data structures and types, Program classification. Computer control: Components of embedded control systems to include terminology and components. Discrete modelling for computer control. PID control in discrete form. Classification of programs, programs for sequential tasks, multitasking systems, real-time systems. Real World Interfacing – LCD, ADC, Sensors, Stepper motor, keyboard and DAC; Real Time Operating System, System Architecture, selection of platform, booting linux, debugging. Interfacing- Asynchronous serial communication interfacing, parallel port interfacing, USB interfacing, Memory interfacing, Synchronous serial communication interfacing, System Integration.

Essential Reading:

1. M. Mazid, J. G. Mazidi, and R. D. McKinlay, ***The 8051 Microcontroller and Embedded System***, Pearson, 2007
2. BARNETT R. H., "The 8051 Family of Micro controller", Prentice Hall 1995
3. B. B. Bray, ***The Intel Microprocessors- 8086/8088, 80186, 80286, 80386, and 80486-Architecture, Programming and Interfacing***, Prentice Hall, 2000.
4. W. A. Triebel and Singh, The 8088 and 8086 Microprocessors, Pearson, 2003

Supplementary Reading:

1. R. Kamal, ***Embedded System***, TMH, 2002
2. Yeralan S AhluwaliaA, "Programming and Interfacing the 8051 Microcontroller"-Addison-Wesley, 1995
3. D. V. Hall, ***Microprocessor and Interfacing programming & Hardware***, TMH, 2001.

EE 345 COMMUNICATION SYSTEMS PRINCIPLES 3 credits [3-0-0]

Analog communication: Band- pass signals and system representation, AM, DSBSC, SSB, VSB, signal representation, generation and demodulation, concepts of mixing, coherent and non-coherent detection, PM, FM and their interrelationship, signal representation, narrow-band and wide-band FM, Carson's rule, generation and demodulation of FM; Pulse and digital communication: Sampling theorem – pulse modulation techniques – PAM, PWM and PPM concepts – PCM encoder and decoder – multiplexing – time division multiplexing and frequency division multiplexing.; Data communication techniques: Data transmission using analog carriers – MODEMS employing FSK, QPSK, QAM and MSK – asynchronous and synchronous transmission – error control techniques – data communication protocols – link oriented protocols – asynchronous protocols.; Television system: Requirement and standards – need for scanning – interlaced scanning – VSB modulation types of camera tubes and picture tubes – B/W and colour systems – PAL – CCTV – Cable TV.; Modern communication systems: Microwave links, Optical communication principles – Satellite communication system – Pagers – Cellular phones – EPABX.

Essential Reading:

1. H. Taub and D. L. Schilling, ***Principles of communication systems,*** McGraw Hill, 1986.
2. S. Haykins, ***An introduction to analog and digital communication systems.*** John Wiley, 1989.

Supplementary Reading:

3. B. P. Lathi, ***Modern Digital and Analog Communication Systems,*** Oxford university press, 1988.
4. K. S. Shanmugam, ***Digital and analog communication systems,*** John Wiley, 1985.

EE 355 COMPUTER ORGANISATION AND ARCHITECHTURE 3 credits [3-0-0]

Stored program concept-Basic operational concepts-Functional units-Machine language-Concept of memory locations, address- Addressing Modes, Instruction formats-Instruction execution-I/O programming-Stacks-Subroutines-Processing Unit-Internal BUS structure (single bus, Two bus, Three bus)-Execution of instructions-Control step sequence.; Hard wired control-design methods- multiplier control unit-CPU control unit; Microprogrammed control-microinstructions-Sequencing.; Addition and subtraction of positive and negative numbers-fast adders-multiplication of positive numbers-signed operand multiplication-fast multilplication-integer division-floating point numbers and operations-Design of arithmetic units.; Basic concepts-semiconductor RAM, ROM memories-Memory interleaving-cache memories-virtual memories-Input-output Organisation-I/O addressing-Data transfer-syncronisation-interrupt handling-I/O interfaces –I/O channels.; Introduction to parallel processing-generation of computer systems-Parallelism in uniprocessor system-parallel computer systems-architectural classification schemes.

Essential Reading:

1. K. Hwang and F. A. Briggs, ***Computer Architecture and parallel processing***, McGraw Hill, Digitized on Nov, 2007.
2. D. Mano and M. M. Mano, ***Computer System Architecture***, Pearson, 2001.

Supplementary Reading:

1. W. Stallings, ***Computer Organization and Architecture,*** Pearson, 2005.

EE 356 DIGITAL SIGNAL PROCESSING 3 credits [3-0-0]

Discrete-Time Signals and Systems: Discrete Time Signals, Analysis of Discrete Time Linear Time Invariant Systems, Systems described by Difference Equation, Correlation of Discrete Time Signals. Design of Digital Filters: Digital Filters by placement of poles and zeros in the Z-plane. Low pass, High pass and band pass Filters, Notch Filter; Comb Filter & All pass Filter. Realization of FIR & IIR systems, Design of FIR Filter using windows, Design of IIR filter by the Bilinear Transformation method. Discrete Fourier Transform : DFT and its relationship to other Transform, properties of the DFT, Circular convolution in time and frequency domains, Linear convolution in time and frequency domain by over lap save and over lap add methods. Fast Fourier Transform: Adaptive Filter, Inverse system, Deconvolution and System Identification. Power Spectrum Estimation: Estimation of Auto correlation and power spectrum of random signals, use of DFT in Power Spectrum Estimation. Parametric method - The Burg Method for the AR Model Parameters, Least Square Method, ARMA Model for Power Spectrum Estimation. The Adaptive Linear Combiner, Wiener Filters, Adaptive Transversal Filter Using Gradient Vector Estimation, LMS algorithm and its convergence analysis.

Essential Reading:

1. J. G. Proakais and D. G. Manolakis, ***Digital Signal Processing: Principles Algorithms and Applications,*** Pearson Education, ***2005.***

Supplementary Reading:

1. A. V. Oppeinheim and R. W. Schafer, ***Digital Signal Processing,*** Pearson Education, 2004.
2. S. K. Mitra, ***Digital Signal Processing: A computer based approach***, TMH, 2001.
3. L. R. Rabiner and B. Gold, ***Theory and Application of Digital Signal Processing,*** Pearson Education, 2004.

EE 370 Power Electronics Lab 2 credits [0-0-3]

SCR and TRIAC characteristic: To measure the Latching and Holding Current of a thyristor: To study the different triggering circuits for thyristor: Resistor triggering circuit; R-C triggering circuit; UJT triggering circuit: To study single phase firing circuit using COSINE wave scheme for triggering Thyristor in single phase bridge converter; Study of 1-pulse converter with R and L load; Study of 2-pulse converter with R and L load; Study of three phase semi converter with R and R-L load; Study of three phase full converter with R and R-L load; Study of single phase dual converter; Study of single phase cycloconverter; To study different types of single phase Ac regulators; AC regulator using Triac; AC regulator using thyristor connected in antiparallel; To study different microprocessor based firing circuit and its application; To study the Power MOSFET/IGBT chopper with varying Frequency and duty cycle; DC Motor control by Impulse commutated single Quadrant chopper; Study of different PWM Schemes; Single pulse; Multiple; Sinusoidal; Trapezoidal; To study a Transistorized Single phase PWM inverter; To study the IGBT based Single phase PWM inverter; DC motor speed control by single phase semi converter and full converter; Speed control of DC motor using three phase half controlled converter; To study the closed loop control of DC motor; To study the operation of four quadrant chopper with DC motor drive; Speed control of three phase induction motor by using three phase IGBT PWM inverter; To study the closed loop control of three phase AC motor; V/f speed control of three phase Induction motor

EE 371 COMMUNICATION SYSTEM LAB. 2 credits [0-0-3]

Amplitude modulation; DSB AM Modulator, Calculation of the modulation index, Observation of the linearity curve of modulator, DSB AM reception using Envelop Decoder, Operation of AM with Suppressed carrier; Study of SSB Signal Generator, SSB Signal Demodulation, Calculate the sensitivity and Selectivity of a AM Receiver; Frequency modulation; Modulation Characteristic of Varactor Modulator, Measurement of frequency; Deviation and calculation of modulation index, Demodulation characteristic of the FM Demodulator (Foster- Seeley Demodulator), Observation of the waveforms of the Foster- Seeley Demodulated signal; Frequency modulation; FM demodulation using Ratio Demodulator, Phase locked loop Detector and Quadrature detector, FM super Heterodyne Receiver; Phase Modulation : Phase Modulation, Phase Demodulation; Analog Signal Sampling and its reconstruction; Natural Sampling and its reconstruction, Sample and Hold and its reconstruction, Flat loop Sampling and its reconstruction, Effect of different sampling frequencies, Effect of varying the sampling frequency duty cycle; Study of TDM Pulse Amplitude Modulation / Demodulation with Transmitter lock and Channel identification information linked directly to the receiver; Sampling and Pulse Code Modulation and Demodulation; Amplitude shift keying modulation Technique, Frequency shift keying modulation Technique and Phase shift keying modulation technique; Delta Modulation and Demodulation / Adaptive Modulation and Demodulation Slope overload and increased integrator gain; Pulse amplitude Modulation, Pulse width Modulation, Pulse position Modulation; Framing in Time Division Multiplexing, Marker in TDM, and PCM voice coding and frequency response of CODEC.

EE 372 CONTROL SYSTEM LABORATORY 2 credits [0-0-3]

Study of a DC motor driven closed loop position control system; Study of a Position Control System using Synchro; Obtain speed-torque characteristics of a two-phase servomotor; Determine the transfer function of a system (network) using a transfer function analyzer; Position and Speed Control of a DC motor using PD and PID Controller via Ziegler Nicholos tuning method; Identification of a DC Motor transfer function; To study the discrete-time version of the PID controller, and to implement classical tuning rules for the digital control system; PID Control with Derivative Filtering and Integral Antiwindup for a DC Servo; Controlling a process using dSPACE / Simulink and LABVIEW; To study and validate the controller type for a temperature control system; To study on the interface of PLC with PC for data acquisition applications; Experimentation of Control loops for Inverted Pendulum.

EE 373 electrical MachineS Lab – II 2 credits [0-0-3]

Determination of regulation of alternator by Synchronous Impedance method; Determination of regulation of alternator by zero power factor method; 'V' and 'Λ' curves of Synchronous Motor; Measurement of X_d & X_q of synchronous machine; Parallel Operation of 3 Phase Alternator with infinite Bus Bar; No load and Blocked rotor test of single phase induction motor; No load and Blocked rotor test of three phase induction motor; Separation of different losses in squirrel-cage Induction Motor; Separation of losses in slip ring Induction motor by Richter's method; Three phase transformer connection; Scott connection of transformer; Determination of sequence impedance of alternator.

EE 374 ELECTRICAL SYSTEMS SIMULATION LAB. 2 Credits [0-0-3]

Basics of Programming in MATLAB (programming structure, Script files, Functions, Debugging programs, Creating functions using m-files, Loops, branches and control flow, Relational and logical operations); MATLAB graphics (Two and three dimensional graphics, Multiple plots, Axis scaling, Printing graphics); Numerical analysis (Non-linear equations and optimization, Differential equations); Introduction to SIMULINK (What can SIMULINK be used for?, Multiple plots creating models, blocks, Systems and sub-systems, Simulating Dynamic System, Solving a model, solvers, MATLAB SIMULINK integration, S-function); MATLAB Toolboxes training (Signal Processing, Neural Network, FUZZY logic, Control System, Communication, Power System toolboxes); LabVIEW(Introduction to LabVIEW, Sources of Information, VirtualInstrumentation, Wiring and Programming Basics, Controls, Indicators and constants, Debugging, Preferences, Chatting, Graphs, Attributenodes, Do & while loops, Forloops, Introduction to data acquisition)

EE 375 EMBEDDED SYSTEM LAB 2 credits [0-0-3]

Write a 8086 based assembly language programme to add the following vectors and Store the result in another vector.;

C = A + B D = A + B + C

The length of the vector should be 10, 15.

Make provision for result to be more than 16 bit.

Determine the average value of the given sample of waveform;

Y (k) = A sin sin3For N = 16, 32, 64

Determine the mean square value of a given data set; Write an ALP for adding and multiplying two 3×3, 4×4, 5×5 matrices; Evaluate the following recursion;

Interface 8086 microprocessor to the given traffic light module and develop the traffic Light system in accordance with a given sequence; Interface the elevator module with the 8086 microprocessors and realize the given condition; Using the given A/D converter sample a sinusoidal, triangular and square waves of different frequency; Using the given A/D and D/A converter and 8086 microprocessor sample and reconstruct a given signal and hence verify the sampling theorem; Interface the given keyboard module using 8051 microcontroller; Interface the given stepper motor and control the steps using 8051 microcontroller; Using the display interface module and microcontroller 8051, show the 7 segment LED display; Using the given PLC interface board and 8086 microprocessor, design a Combinational controller and Sequential controller; Speed Control of DC Motor using 8051 microcontroller; Path tracing controlling using microcontroller; Design of an Adaptive FIR Filter using 8051 microcontroller.

EE 377 ELECTRICAL MACHINE DESIGN 2 credits [0-0-3]

Solving problems from '***Problems in Electrical Engineering***' by Parker Smith; Design of single phase / three phase, core type / shell type transformers; Drawing of the designed transformer using AUTOCAD; Design of DC machine; Drawing of the designed DC machine using AUTOCAD; Design and Drawing of the armature winding of DC machine.

EE 401 POWER SYSTEM OPERATION & CONTROL 4 credits [3-1-0]

Fundamentals of Power System : Concepts of real and reactive powers, complex power, per-unit representation of power system, Transmission capacity, load characteristics, real power balance and its effect on system frequency, load frequency mechanism, reactive power, balance and its effect, on-load tap changing transformer and regulating transformer.; Power Circle diagram: Receiving and sending end power circle diagram, universal power circle diagram, use of power circle diagram.; Load flow analysis: Static load flow equation for a low-bus system, characteristics of a load flow equation, generalization to n-bus system, Gauss-Seidel and Newton-Raphson method of solution of load flow equations for 2 bus and 3 bus system.; Load frequency control : Automatic voltage, regulator, exciter modelling, generator modelling and static performances of AVR loop, automatic load frequency, control of single area systems, speed governing system, hydraulic valve actuator, turbine generator response, static performance of speed governor, closing the ALFC loop, Concept of control area static response of primary ALFC loop, dynamic response of ALFC loop, ALFC for multicontrol area system, the two area system, modelling of the tie-line block diagram representation of two are system, static response of two area system, dynamic response of two area system, dynamic response of two area system tie-line bias control, tie-line bias control of two area system, static response, steady state instabilities.; Economic Operation of power system : Distribution of load between units within a plant, transmission loss as function of plant generation, calculation of loss-coefficient, distribution of loads between plants with special reference to steam and hydel plants, automatic load dispatching.; Power system stability: Steady state stability, transient stability, swing equation, equal area criteria for stability methods of improvement of transient stability.

Essential Reading:

1. W. D. Stevenson, ***Elements of Power system analysis,*** Mcgraw Hill, Digitized on Dec., 2007.
2. A. Chakrabarti and S. Halder, ***Power System Analysis: Operation and Control***, PHI, 2006.

Supplementary Reading:

1. T. K. Nagsarkar and M. S. Sukhija, ***Power System Analysis,*** Oxford University Press, 2007.
2. I. J. Nagrath and D. P. Kothari, ***Modern Power System Analysis***, TMH, 2003.

EE 404 RENEWABLE ENERGY SYSTEMS 3 credits [3-0-0]

Introduction to Energy Sources: Energy sources and their availability, Non-renewable reserves and resources; renewable resources, Transformation of Energy, Solar Power: Solar processes and spectral composition of solar radiation; Radiation flux at the Earth's surface. Solar collectors. Types and performance characteristics. Applications : Wind Energy: Wind energy conversion; efficiency limit for wind energy conversion, types of converters, aerodynamics of wind rotors, power ~ speed and torque ~ speed characteristics of wind turbines, wind turbine control systems; conversion to electrical power: induction and synchronous generators, grid connected and self excited induction generator operation, constant voltage and constant frequency generation with power electronic control, single and double output systems, reactive power compensation; Characteristics of wind power plant. Applications: Tidal Energy: Wave characteristics. Conversion systems and their performance features. Application, Geothermal energy: Biological conversion of Energy.

Essential Reading:

1. D. P. Kothari, K. C. Singal, R. Ranjan, ***Renewable Energy Sources and Emerging Technologies***, Prentice Hall of India, New Delhi, 2008.

Supplementary Reading:

1. S. N. Bhadra, D. Kastha, S. Banerjee, ***Wind Electrical Systems***, Oxford Univ. Press, New Delhi, 2005.
2. S. A. Abbasi, N. Abbasi, ***Renewable Energy Sources and Their Environmental Impact***, Prentice Hall of India, New Delhi, 2006.

EE 405	UTILIZATION OF ELECTRICAL ENERGY & ELECTRICAL DRIVES	4credits [3-1-0]

Single phase fully controlled rectifier, Control of separately excited D. C. Motor, Single phase half controlled rectifier, Three phase fully controlled and half controlled rectifier, control of separately excited D. C. Motor, Dual converter control of separately excited D. C. Motor Chopper controlled D. C. Drives. Closed loop control of D. C. Drives PLL Control of D. C. Drives.; Stator speed control methods of Induction Motor, Stator voltage control, Slip power recovery scheme, Variable voltage and frequency control, (V/1) control, C. S. I feed Induction Motor drives, Closed loop control of Induction Motor, Cycloconverters and Synchronous Motor drives.; Classification of Electrical drives, Types of load, Quadrant diagram of Speed-Torque characteristics, Dynamics of motor load combination, Steady state stability of Electrical drives starting and braking D. C. Motors and Induction Motors. Calculation of time and energy loss in transient operation.; Illumination, Electrical heating, Furnaces, Arc welding, Industrial application of motors in steel mills, Textile mills, Cement mill and paper mills.; Electric Traction services, Nature of traction load, Main line and sub-urban train configuration, Braking, Power factor and harmonics, Calculation of traction drive rating and energy consumption, Traction motor, Conventional D. C. and A. C. traction drives, Diesel Electric traction .

Essential Reading:

1. G. K. Dubey, ***Fundamentals of Electrical Drives***, Narosha Publishing House, 2001.
2. H. Partab, ***Modern Electric Traction, DhanpatRai, 1992.***

Supplementary Reading:

1. P. K. Sen, ***Electric Drives,*** PHI, 2001.
2. S. K. Pillai, ***A first course in electrical drives***, New Age international***, 1989.***

EE 406	HIGH VOLTAGE DC TRANSMISSION	3 credits [3-0-0]

D. C. Power Transmission Technology: Introduction, Comparison of AC and DC Transmission, Application of DC Transmission, Description of DC Transmission System, Planning for HVDC transmission. Modern Trends in DC transmission. Thyristor Valve; Introduction, Thyristor devices, Thyristor valve, Valve test, recent trends. Analysis of HVDC Converters; Pulse Number, Choice of converter configuration, Simplified analysis of graetz circuit, Convertor bridge characteristics, Characteristics of a twelve pulse converters, Detailed analysis of converters.; Converter and HVDC system Control: General, Principles of DC Link control, Converter control characteristics, System control hierarchy Firing angle control, current and extinction angle control, Starting and stopping of DC link, Power Control, Higher level controllers, Telecommunication requirements.; Converter Faults and Protection: Introduction, Converter Faults, Protection against over currents over voltages in a converter station, Surge arrests, Protection against over voltages. Smoothing Reactor and DC Line; Introduction, Smoothing reactors, DC Line, transient over voltages in DC Line, Protection of DC line, DC breakers, Monopolar operation, Effects of proximity of AC and DC Transmission lines. Reactive Power Control; Introduction, Reactive power requirements in steady state, Sources of reactive power, Static var systems, Reactive power control during transients. Harmonics and Filters; Introduction, Generation of Harmonics, Design of AC Filters, DC Filters, Carrier frequency and RI noise. Multiterminal DC systems; Introduction, Potential applications of MTDC systems, Types of MTDC systems, control and protection of MTDC systems, Control and protection of MTDC Systems study of MTDC systems.

Essential Reading:

1. K. R. Padiyar, ***HVDC Power transmission System,*** New age International***, 1996.***

Supplementary Reading:

1. J. Arrillaga, ***HVDC transmission***, IET, 1998.

EE 407	POWER ELECTRONIC DRIVES	4 credits [3-1-0]

Factors affecting selection of drives, speed-torque characteristics of motors and loads, condition of steady-state stability, transient stability: equal area criterion, dynamics of motor load combination, DC shunt motor and series motor braking methods and speed-torque characteristics in four quadrants, Induction motor: steady-state performance analysis, braking methods, four quadrant speed-torque characteristics, dc and ac dynamic braking, Methods of starting, energy relations during starting and braking, Transients in dc and ac drives; Motor and converter performance parameters, 1-phase full- and semi- converter fed dc shunt and dc series motor, Mathematical analysis of 1-phase converter fed dc motors, 1-phase Dual converter: waveforms, operations with and without circulating current, 3-phase full converter, semi converter and dual converter fed dc drives, Power factor considerations of semi- and full converters, Power factor improvement of phase controlled converters, Sequence control of converters, Chopper controlled dc drives; Static speed control of induction motor: stator voltage control, Static control of rotor resistance, Static slip power recovery scheme, VSI and cyclo-converter fed drives, V/f control, constant torque and constant power operations, closed loop V/f control, CSI fed drives; Induction motor behavior with non-sinusoidal supply and unbalanced supply, PWM inverters and reduction of harmonics, Synchronous motor drives: true and self synchronous modes, hunting; Brushless dc motor drive, Reluctance motor, SRM, stepper motors; Illumination, electrical heating, furnaces, arc welding, industrial application of motors in steel mills, textile mills, cement mill and paper mills; Electric traction services, nature of traction load, main line and sub-urban train configuration, traction mechanics, traction drives, braking, power factor and harmonics, traction motor.

Essential Reading:

1. G. K. Dubey, Fundamentals of Electrical Drives, Narosha Publishing House, 2001.
2. S. K. Pillai, A first course in electrical drives, New Age International, 1989.

Supplementary Reading:

1. H. Partab, Modern Electric Traction, DhanpatRai, 1992.

EE 416	**POWER SYSTEM TRANSIENTS**	**3 credits [3-0-0]**

Theory of traveling waves and standing waves: Travelling waves and standing waves at power frequency, differential equations and solutions for general case, standing waves and natural frequencies, open ended line- double exponential response, open ended line – response to sinusoidal excitation, line energization with trapped charge voltage, reflection and refraction of traveling waves, transient response of systems with series and shunt lumped parameters and distributed lines, principle of traveling wave protection.; Lightning and lightning protection: Lightning stroke to lines, lightning stroke mechanism, general principles of lightning protection problem, tower footing resistance, insulator flashover and withstand voltage, probability of occurrence of lightning-stroke currents, lightning arresters and protective characteristics, dynamic voltage rise and arrester rating, operating characteristics of lightning arresters, insulation coordination based on lightning.; Over voltages in EHV systems caused by switching operations: Origin of overvoltages and their types, overvoltages caused by interruption of low inductive currents, ferro-resonance overvoltages, calculation of switching surges – single phase equivalents, distributed parameter line energized by source, generalize equations for three phase systems, reduction of switching surges on EHV systems.; Frequency of occurrence of lightning flashes and shielding of transmission lines: Interaction between conductors, electrostatic field due to the leader stroke, calculation of shielding angle, frequency of occurrence of lightning flashes to transmission line, the electrostatic field at earth as a function of leader stroke charge, Approximate calculation of area of attraction, Frequency of occurrence of lightning flashes.; Transient studies of FACTS and custom power equipment: Electromagnetic transient analysis, electromagnetic transient simulator, static compensator, dynamic voltage restorer, solid state transfer switch.

Essential Reading:

1. R. D. Bagamudre, ***Extra high voltage AC transmission engineering,*** Wiley Eastern Ltd., 1990.
2. C. S. Indulkar & D. P. Kothari, ***Power System Transients,*** PHI, 1996.

Supplementary Reading

1. E Acha, V. G. Agelidis, O Anaya-Lara & T. J. E. Miller, ***Power Electronic control in electrical systems***, Newnes, 2002.

EE 417	**HIGH VOLTAGE ENGINEERING**	**4 credits [3-1-0]**

Conduction and breakdown in Gaseous Dielectrics: Townsend's current growth equation, current growth in the presence of secondary processes, Townsend's criterion for breakdown, experimental determination of coefficients and breakdown in electronegative gases, time lags for breakdown, streamer theory of breakdown in gases, Paschen's law, penning effect. Breakdown in non-uniform fields and corona: post-breakdown phenomena and applications, practical considerations in using gases for insulation purposes. Conduction and Breakdown in Liquid dielectrics: Pure liquids and commercial liquids, conduction and breakdown in commercial liquids. Breakdown in solid Dielectrics: Intrinsic breakdown, electromechanical breakdown, thermal breakdown, breakdown of solid dielectrics in practice. Use of insulating materials in power transformers, rotating machines, cables, power capacitors, electronics equipment. Generation of High voltages: Generation of high D. C. voltage, high a. c. voltage, impulse voltage, impulse current, tripping and control of impulse generators. Measurement of high voltages and current: Measurement of high d. c. high a. c. and impulse. Non-Destructive Testing of Materials and Electrical Apparatus: Measurement of d. c resistivity, dielectric constant and loss factor, partial discharge. H. V. Testing of Electrical Apparatus: Testing of insulators, bushings, isolators, circuit breakers, cables, transformers, surge diverters. Design, planning and layout of H. V. laboratories: Layout of high voltage laboratories, grounding of impulse testing laboratories.

Essential Reading:

1. M. S. Naidu and V. Kamaraju, ***High voltage Engineering***, Tata McGraw Hill, 1995.
2. J. Kuffel and W. S. Zaengl, ***High Voltage Engineering: Fundamentals***, Newnes, 2000.

Supplementary Reading:

1. 1. C. L. Wadhwa, ***High Voltage Engineering***, New Age, 2007.

EE 425	**CONTROL SYSTEM – II**	**4 credits [3-1-0]**

State Space Analysis: Review of State space representation of Control system Diagonalisation, Controlability and Observability, State feedback control, pole placement trough State feedback, Observer Design, Linear Quadratic Regulator; Digital Control System: Introduction to discrete-time systems, Signal Processing in Digital Control, Models of Digital Control Devices and Systems, Design of Digital Control Algorithms Controls, State-variable analysis of Digital Control Systems. Microcontroller/Microprocessor based Digital Control Implementation. PLC; Lyapunov Stability Analysis: Stability Definitions, Stability Theorems, Examples Non Linear Control System: Characteristics of Nonlinear Systems, Common non-linearities. Phase plane, describing function techniques.

Essential Reading:

1. K. Ogata, ***Modern Control Engineering,*** Pearson, 2003
2. N. S. Nise, ***Control Systems Engineering, 4th Edition*****,** 2004

Supplementary Reading:

1. M. Gopal, ***Control Systems: Principles and Design***, TMH, 2008
2. R. C. Dorf and R. H. Bishop, ***Modern Control Systems***, Prentice-Hall, 2007

EE 426	FUZZY MODELLING AND CONTROL	3 credits [3-0-0]

Fuzzy Representation of uncertainty, classical sets and fuzzy sets, properties of fuzzy sets, fuzzy set operations, Fuzzy Relations, fuzzy inference and defuzzification techniques, Mamdani and Sugeno fuzzy systems, fuzzy logic control design, different types of fuzzy control (PI/PD/PID), Tuning of fuzzy system parameters(Scale factor/Membership Function/Rule Base).; Stability Analysis of fuzzy control systems, Fuzzy System as Universal Approximators, fuzzy modeling and identification, Adaptive Fuzzy Control; Neuro-fuzzy system, evolutionary fuzzy systems.; Application of fuzzy system to electric drives.

Essential Reading:

1. T. J. Ross, ***Fuzzy Logic with Engineering Application***, John Wiley and Sons, 2004.
2. R. R. Yager and D. P. Filev, ***Essentials of Fuzzy Modelling & Control***, John Wiley & Sons, 2002

Supplementary Reading:

1. D. Driankov, H. Hellendoorn, M. Reinfrank, ***An Introduction to Fuzzy Control***, Springer-Verlag, 2001
2. Li-Xin Wang, ***Adaptive Fuzzy Systems and Control: Design and Stability Analysis***, 2007

EE 427	**SOFT COMPUTING**	**4 credits [3-1-0]**

Introduction to Neorofuzzy and Soft Computing, Fuzzy set theory, Fuzzy Rules, Fuzzy Reasoning, Fuzzy inference System, Neural Networks; Radial basis and recurrent neural networks, Hopfield Networks, Comparision of RBF and MLP Network, Running Algorithms, NeuroFuzzy Modeling, Applications of Soft Computing to Signal Processing, Image Processing, Forecasting, XOR Problem-traveling salesman problem, Image compression suing MLPs-character retrieval using hopfield networks, Introduction to Genetic Algorithm hybrid Systemsetc.

Essential Reading:

1. V. Kecman, ***Learning and Soft Computing***, Pearson, 1st Ed, 2001.
2. D. E. Goldberg, ***Genetic Algorithms in Search Optimization and Machine Learning***, Addison Wesley, 3rd Ed.

Supplementary Reading:

1. B. Kosko, ***Neural Network and fuzzy systems***, Prentice Hall of India, 2006.
2. S. Goonatilake & S. Khebbal, ***Intelligent Hybrid Systems***, Wiley, 1995.

EE 428 ELECTRICAL DRIVES CONCEPTS & APPLICATIONS 3 credits [3-0-0]

Classification of Electrical drives, Types of load, Quadrant diagram of Speed-Torque characteristics, Dynamics of motor load combination, Steady state stability of Electrical drives, starting and braking D. C. and Induction Motors, Calculation of time and energy loss. Industrial application of motors in steel mills, Textile mills, Cement mill and paper mills. Electric Traction services: Nature of traction load, Main line and sub-urban train configuration, Braking, Power factor and harmonics, Calculation of traction drive rating and energy consumption, Traction motor, Conventional D. C. and A. C. traction drives. Recent trend in electric drives.

Essential Reading:

1. S. K. Pillai, ***A first course in electrical drives:*** Wiley Eastern, 1994.

Supplementary Reading:

1. G. K. Dubey, ***Fundamentals of Electrical Drive***, Narosa Publishing House, 2001.
2. V. Subrahmanyam, ***Electric Drives: Concepts and Applications***, Tata McGraw Hill, New Delhi, 2005.

EE 429 ADVANCED CONTROL THEORY 3 credits [3-0-0]

State-space approach to linear system theory. Mathematical background in linear algebra (vector space, fields, linear independence, inner product, etc.), solutions of state equations (time varying and time invariant systems), Jordan form, controllability, eigenvalue assignment using state feedback, observability, designing observers, separation principle, Kalman filters.; Data conversion effects, Loop performance and sampling rate selection; Difference equations; Discrete PID: Positional and incremental form; PID algorithm including integral windup and derivative kick solution; Discrete PID controller; Design of optimal control systems, linear quadratic regulators, linear quadratic Gaussian optimal control, Ricatti equation, suboptimal control, dynamic programming, calculus of variations, and Pontryagin's minimum principle. Nonlinear control design techniques; Feedback linearization, input-state and input-output linearization, design issues for MIMO nonlinear systems. Variable structure control, sliding surface design, approximation of switching laws.; Neural networks and fuzzy logic systems for feedback control.

Essential Reading:

1. M. Gopal, ***Digital Control and State Variable Methods***, Tata McGraw-Hill, 2003
2. G. F. Franklin, J. G. Powell and M. L. Workman, ***Feedback Control of Dynamic Systems,*** Pearson Higher Education, 2002

Supplementary Reading:

1. B. Friedland, ***Control System Design - An Introduction to State-Space Methods***, McGraw-Hill, Digitized Dec 5, 2007
2. K. Ogata, ***Modern Control Engineering***, Prentice Hall, 2002.
3. R. C. Dorf and R. H. Bishop, ***Modern Control Systems***, Prentice Hall, 2004.

EE 436 ADAPTIVE CONTROL AND SYSTEM IDENTIFICATION 3 credits [3-0-0]

Introduction and overview of Systems Identification, Adaptive Control and applications. Parameter Estimation: Least Square, Generalized and Recursive Least Square, Estimator properties including error bounds and convergence, MES, ML and MAP estimators, Nonlinear Least Squares. Model Structures and Predictors. Recursive Identification of Linear dynamic systems: RLS, ELS, IV, RML, Stochastic Approximation, Extended Kalman Filter, generalized prediction error framework and its application to ARMA and state models, convergence analysis, Time varying parameters.; Adaptive schemes. Adaptive control theory. Applications.; Situations when constant Gain feedback is insufficient.; Robust control. The adaptive control problem.; The model following problem. MRAS based on stability theory. Model following when the full state is measurable. Direct MRAS for general linear systems. Prior knowledge in MRAS. MRAS for partially known systems. Use of robust estimation methods in MRAS.; The basic idea. Indirect self-tuning regulators. Direct Self-tuning regulators. Linear Quadratic STR. Adaptive Predictive control. Prior knowledge in STR.

Essential Readings:

1. K. J. Astrom and B. Wittenmark, ***Adaptive Control***, Addison - Pearson, 2006.
2. L. Ljung, ***System Identificaiton: Theory for the user***, Prentice -Hall, 2007.

Supplementary Reading:

1. Landau and Zito,

EE 438 INDUSTRIAL AUTOMATION & CONTROL 3 credits[3-0-0]

Prerequisite: Control System Engineering-I; Introduction to Industrial Automation Systems; Measurement of physical quantities, e.g., temperature, pressure, force, displacement, speed, liquid flow, liquid level humidity.

Signal conditioning and calibration.; Actuators, Control Valves, Hydraulic Actuation, Switches and Gauges, Industrial Hydraulic Circuits, Pneumatic Control Systems.; Introduction to Process Control, PID control, Auto-tuning, Predictive control.; Programmable Logic Controllers (PLC), Modelling of Sequence Control Specifications and Programming.; Electrical Machine Drives, Energy Savings with Variable Speed Drives, Stepper Motors, DC Motor Drives, Induction Motor Drives, BLDC Motor Drives.; Industrial Real Time Embedded Systems, Process Management, Control Networks.

Essential Reading:

1. Smith Carlos and Corripio, "***Principles and Practice of Automatic Process Control***", John Wiley & Sons, 2006.
2. Jon Stenerson, "***Industrial Automation and Process Control***", Prentice Hall, 2003.
3. M. Gopal, "***Digital cControl and State Variable Methods***" Tata McGraw Hill, 2003.

Suggested Reading:

1. G. F. Franklin, J. D. Powell, M. L. Workman: Digital Control of Dynamic Systems, Addison-Wesley, Reading, Ma-USA (1990)

EE 445	DATA COMMUNICATION AND NETWORKS	4 credits [3-1-0]

Data Communications, Data Encoding, Data Communication Interface, Data Link Control, Wide Area Networks: Circuit Switching; Packet Switching, Routing, Congestion Control, Frame Relay; Asynchronous Transfer Mode, Local Area Networks, Communications Architecture and Protocols: OSI, TCP/IP Protocol, Internetworking, ISDN and Broad Band ISDN.

Essential Reading:

1. W. Stallings, ***Data and Computer Communications***, Prentice Hall of India, New Delhi, 1997.

Supplementary Reading:

1. A. S. Tannenbam, ***Computer Networks***, Prentice Hall of India, 1997.

EE 454	DIGITAL COMMUNICATION	3 credits [3-0-0]

Fundamental Limits on Performance : Uncertainly, Information and Entropy, Source coding theorem, Huffmann coding, Discrete memory less channels, Mutual information, Channel capacity, channel coding theorem, Differential Entropy and mutual information for continuous ensembles, Channel Capacity Theorem.; Detection and Estimation: Model of Digital communication system, Gram-Schmidt Orthogonalization Procedure, Geometry Interpretation of Signals, Response of Bank of correlators to Noisy Input, Detection of known signals in Noise, Probability of Error, Correlation receiver, Matched Filter Receiver, Detection of signals with unknown phase in Noise, Estimation : Concepts and criteria, Maximum Likelihood Estimation : Wiener Filter for Ware form Estimation, Linear Prediction : Linear Predictive Vocoders, Adaptive Filters.; Waveform coding Techniques: Robust quantization, Differential Pulse-code Modulation, Delta Modulation, Coding speech at Low Bit Rates.; Digital Modulation Techniques : Comparison of Binary and Quarternary modulation techniques, Modulation Techniques, power Spectra, Bandwidth Efficiency, Mary, Modulation Formats Viewed in the Eight of Channel capacity theorem, Effect of Inster symbol Interference, Bit Versus symbol error probabilities Synchronization, Applications, Voice-grade Modems, Digital Radio, Digital communications by Satellite.; Error Control Coding : Rationale for coding and types of codes, Discrete memory less channels, Linear block codes, Cyclic codes, Convolutional codes, Maximum likelihood decoding of convolutional codes, Distance properties of convolutional codes, Sequential decoding of convolutional codes, Trollis codes.; Applications: Coding for white Gaussian Noise Channels, Coding for compound error channels, Block codes for error control in Date storage.; Spread Spectrum Communication : Pseudo noise sequences, A notion of spread spectrum, Direct sequence spread acoherent binary phase-shift keying, Signal space Dimensionality and processing gain, Probability of Error, Frequency Hop spread spectra. Applications: Code division multiple access, Multi path Suppressio

Essential Reading:

1. S. Haykin, ***Digital Communications,*** John Wiley, 1988.
2. J. Proakis, ***Digital Communication***, Mcgraw Hill, 2001.

Supplementary Reading:

1. R. Bose, ***Information Theory Coding and Cryptography,*** TMH, 2002.

EE 456	ROBOTICS AND COMPUTER VISION	3 credits [3-0-0]

Robots and automation-classification-specifications-notation-Direct Kinematics-Co-ordinate frames-rotations-Homogeneous coordinates-The Arm equation-Kinematic analysis of a typical Robot-examples-Inverse Kinematics problem-Tool configuration-Inverse kinematics of a typical Robot-examples-Workspace analysis and trajectory planning-Work envelope of different robots-The pick and place operation –Continuous path motion-interpolated motion-Straight line motion-Tool configuration Jacobian matrix and manipulator Jacobian-Manipulator Dynamics-Dynamic model of a robot using Lagrange's Equation R-The control problem-state equations-Single axis PID control-PD gravity control-Computed torque control-Variable Structure control-Impedance control; Discrete geometry and quantization, length estimations, automated visual inspection, object recognition and matching, depth perception problems, stereo geometry and correspondence, motion analysis, optical flow, multi-resolution processing of images, applications of Computer Vision, remote sensing, biomedical imaging, document processing, target tracking.

Essential Reading:

1. L. Sciavicco and B. Siciliano, ***Modeling and Control of Robot Manipulators***. Springer, 2007
2. F. L. Lewis, D. M. Dawson, and C. T. Abdallah, ***Robot Manipulator Control: Theory and Practice,*** Revised and Expanded, Marcel Dekker, New York, 2004.
3. K. S. Fu, R. C. Gonzalez and C. S. G Lee, ***Robotics: Control, Sensing, Vision, and Intelligence***, McGraw Hill, NY, 1987.

Supplementary Reading:

1. J. J. Craig, ***Introduction to Robotics, Mechanics and Control***, Addison Wesley, MA. Digitized Dec 4, 2007
2. R. J. Schilling, ***Fundamentals of Robotics Analysis and Control***, Prentice Hall, NJ, Digitized Dec 5, 2007

EE 471 ELECTRIC DRIVES LAB 2 credits [0-0-3]

Speed control of DC motor by single phase fully controlled converter; Speed control of DC motor using 3-Phase full converter 3-Phase semi converter; Closed loop control of DC motor; Four quadrant chopper controlled DC motor drive; Speed control of 3-Phase induction motor using 3-Phase IGBT based PWM inverter; Speed control of DC & AC motor using ASIPM based power module; Stepper motor speed control; Closed loop control of 3-Phase induction motor.

EE 472 CONTROL & ELECTRICAL SYSTEM DESIGN 2 credits [0-0-3]

Designing an electronic scale for measuring weight; Objective: Explore the specifications of weigh scale; Design a electronic weigh-scale system. Focus Area: Filtering; A/D converter dynamic range; Peak to peak noise resolution. Controller design for dc-dc converter: Objective: Explore the specifications of dc-dc converter; Design the controller to regulate the output voltage. Focus Area: Steady state modeling for power stage design, Dynamic modeling for controller design, Controller design. Load frequency control for power system: Objective: To study and design load-frequency controller, Focus Area: Modeling from specifications; Performance determination; Controller design; Design of controllers for robotic manipulator; Objective: To study and design robotic manipulator; Focus Area: Modeling; Various controller designs.

DEPARTMENT OF INDUSTRIAL DESIGN

DETAILED SYLLABI OF COURSES

Sub. Code	Subject	L-T-P	Credits
ID 200	Design and Society	3-0-0	3
ID 220	Fundamentals of Computer Graphics and Solid Modeling	3-0-0	3
ID 221	Mechanisms and Machines	3-1-0	4
ID 222	Geometric and Solid Modeling	3-1-0	4
ID 230	Environmental and Experimental Design	3-0-0	3
ID 232	Art and Aesthetic Design	3-1-0	4
ID 272	Design workshop - II	0-0-3	2
ID 310	Value Engineering	3-0-0	3
ID 311	ProductDesign - I	3-1-0	4
ID 312	ProductDesign - II	3-1-0	4
ID 321	Thermal Considerations in Design	3-0-0	3
ID 333	Interaction Design and Usability Engineering	3-0-0	3
ID 341	Manufacturing Processes	3-1-0	4
ID 344	Design of Production Tooling	3-1-0	4
ID 350	Robotics and Automation	3-0-0	3
ID 351	Industrial Mechatronics	3-0-0	3
ID 352	Industrial Robotics	3-1-0	4
ID 354	InstrumentationandControl	3-0-0	3
ID 371	Art, Design and Aesthetic Laboratory	0-0-3	2
ID 372	Designworkshop-II	0-0-3	2
ID 373	ProductDesignLaboratory – I	0-0-3	2
ID 374	ProductDesignLaboratory – II	0-0-3	2
ID 376	Creative Automation Laboratory	0-0-3	2
ID 381	Industria Design Project - I	0-0-3	2
ID 382	Industria Design Project - II	0-0-3	2
ID 391	Special Topic in Industrial Design - I		3/4
ID 392	Special Topic in Industria lDesign - II		3/4
ID 393	Special Laboratory in industrial Design - I	0-0-6	4
ID 394	Special Laboratory in industrial Design - II	0-0-6	4
ID 410	Project Management	3-0-0	3
ID 431	Ergonomics in Design	3-1-0	4
ID 432	System Design for Sustainability	3-0-0	3
ID 433	Visual Design	3-0-0	3
ID 434	Photo Communication	3-0-0	3
ID 440	Rapid Prototyping	3-0-0	3
ID 441	Computer Aided Manufacturing	3-1-0	4
ID 442	Rapid Product Development Technologies	3-1-0	4
ID 444	Design for Manufacture and Assembly	3-1-0	4
ID 451	Industrial Automation	3-0-0	3

ID 471	Ergonomics Simulation Laboratory	0-0-3	2
ID 491	ResearchProject–I	0-0-6	4
ID 492	ResearchProject–II	0-0-9	6
ID 493	Seminar & TechnicalWriting–I	0-0-3	2
ID 494	Seminar & TechnicalWriting–II	0-0-3	2
ID 495	Short Term Industrial/ResearchExperience	0-0-0	2
ID 496	Comprehensive Viva - Voce	0-0-3	2

For B. Tech Courses (3 or 4 level) please refer to the B. Tech Curriculum and Syllabi, for M. Tech Courses (6 level) please refer to M. Tech Curriculum and Syllabi.

ID210 FUNDAMENTALS OF COMPUTER GRAPHICS AND SOLID MODELING 3Credits[3-0-0]

Introduction to Computer Graphics: Overview of Computer Graphics, Computer Graphics Application and Software, Description of some graphics devices, Input Devices for Operator Interaction, Active and Passive Graphics Devices, Display Technologies, Raster Refresh (Raster-Scan) Graphics Displays, Cathode Ray Tube Basics, Color CRT Raster Scan Basics, Video Basics, The Video Controller, Random-Scan Display Processor, LCD displays, Rasterization, Algorithm for Rasterization of straight lines and circles, Scan conversion – lines, circles; **Two-Dimensional Transformations:** Transformation Conventions, 2D Transformations, Homogeneous Coordinates and Matrix Representation of 2D Transformations, Translations and Homogeneous Coordinates, Rotation, Reflection, Scaling, Combined Transformation, Solid Body Transformations, Rotation About an Arbitrary Point, Reflection through an Arbitrary Line; **Three-Dimensional Transformations:** Introduction, Three-Dimensional Scaling, Three-Dimensional Shearing, Three-Dimensional Rotation, Three-Dimensional Reflection, Three-Dimensional Translation, Multiple Transformation, Rotation about an Arbitrary Axis in Space, Reflection through an Arbitrary Plane, Matrix Representation of 3D Transformations, Composition of 3D Transformations, Affine and Perspective Geometry, Perspective Transformations, Vanishing Points, Orthographic Projections, Axonometric Projections, Oblique Projections; **Curves and Surfaces:** Curve Representation, Parametric Curves, Parametric Representation of a Circle, Parametric Representation of an Ellipse, Parametric Representation of a Parabola, Parametric Representation of a Hyperbola, Representation of Space Curves, Cubic Splines,, Bezier Curves, B-spline Curves, Parametric Cubic Curves, Bezier Surfaces, B-spline Surfaces. **Solid Modeling:** Representation Schemes, Fundamentals of Solid Modeling, Data Representation Schemes, B-Reps, Constructive Solid Geometry, Graphics Programming using OpenGL.

Essential Readings:

1. J. D. Foley, A. Van Dam, S. K. Feiner and J. F. Hughes, ***Computer Graphics - Principles and Practice***, Second Edition in C, Pearson Education, 2003.
2. D. Hearn and M. Pauline Baker, ***Computer Graphics (C Version)***, Pearson Education, 2nd Edition, 2004.
3. D. F. Rogers and J. A. Adams, ***Mathematical Elements for Computer Graphics***, 2nd Edition, McGraw-Hill International Edition, 1990.
4. F. S. Hill Jr., ***Computer Graphics using OpenGL***, Pearson Education, 2003.

Supplementary Readings:

1. D. F. Rogers, ***Procedural Elements for Computer Graphics***, 2nd Edition, Tata McGraw-Hill Edition, New Delhi, 2001.
2. Saxena and V. Sahay, ***Computer-Aided Engineering Design***, Springer, 2005.

ID 212 COMPUTER GRAPHICS AND SOLID MODELING 4 Credits [3-1-0]

Introduction to Computer Graphics: Overview of Computer Graphics, Computer Graphics Application and Software, Description of graphics devices, Input Devices for Operator Interaction, Display Technologies, Raster Refresh (Raster-Scan) Graphics Displays, Cathode Ray Tube Basics, Color CRT Raster Scan Basics, Video Basics, The Video Controller, Random-Scan Display Processor, LCD displays, Rasterization, Scan conversion – lines, circles, Line-Drawing Algorithms, Circles-Generating Algorithms, Ellipse-Generating Algorithms, Graphics pipeline, Clipping; **Two-Dimensional Transformations:** Transformation Conventions, 2D Transformations, Homogeneous Coordinates and Matrix Representation of 2D Transformations, Translations and Homogeneous Coordinates, Rotation, Reflection, Scaling, Combined Transformation, Solid Body Transformations, Rotation about an Arbitrary Point, Reflection through an Arbitrary Line; **Three-Dimensional Transformations:** Introduction, Three-Dimensional Scaling, Three-Dimensional Shearing, Three-Dimensional Rotation, Three-Dimensional Reflection, Three-Dimensional Translation, Multiple Transformation, Rotation about an Arbitrary Axis in Space, Reflection through an Arbitrary Plane, Matrix Representation of 3D Transformations, Composition of 3D Transformations, Affine and Perspective Geometry, Perspective Transformations, Vanishing Points, Orthographic Projections, Axonometric Projections, Oblique Projections; **Curves and Surfaces:** Curve Representation, Parametric Curves, Parametric Representation of a Circle, Parametric Representation of an Ellipse, Parametric Representation of a Parabola, Parametric Representation of a Hyperbola, Representation of Space Curves, Parametric Cubic Curves, Cubic Splines,, Bezier Curves, B-spline Curves, Rational B-spline curves, Bezier Surfaces, B-spline Surfaces, Rational Parametric Surfaces; **Solid Modeling:** Solid Modeling-Introduction, Properties of Geometric Solid, Solid Representation, Representation Schemes, Fundamentals of Solid Modeling, Data Representation Schemes, Pure Primitive Instancing, Half spaces, Spatial Occupancy Enumeration, Cell Decomposition, Octree Encoding, Constructive Solid Geometry (CSG), Boundary Representation (B-Rep), Sweep Representation, Analytical Solid Modeling; Graphics Standards for CADGraphics and Computing standards - GKS - Bitmaps - Open GL - Data Exchange standards - IGES - STEP - CALS - DXF.

Essential Readings:

1. J. D. Foley, A. Van Dam, S. K. Feiner and J. F. Hughes, ***Computer Graphics - Principles and Practice***, Second Edition in C, Pearson Education, 2003.
2. D. Hearn and M. Pauline Baker, ***Computer Graphics (C Version)***, Pearson Education, 2nd Edition, 2004.
3. D. F. Rogers and J. A. Adams, ***Mathematical Elements for Computer Graphics***, 2nd Edition, McGraw-Hill International Edition, 1990.
4. D. F. Rogers, ***Procedural Elements for Computer Graphics***, 2nd Edition, Tata McGraw-Hill Edition, New Delhi, 2001.

Supplementary Readings:

1. Saxena and V. Sahay, ***Computer-Aided Engineering Design***, Springer, 2005.
2. F. S. Hill Jr., Computer Graphics using OpenGL, Pearson Education, 2003.

ID 230 PRODUCTION MANAGEMENT 3 Credits [3-0-0]

Introduction: Definition, scope and objectives of Production Management, Relationship of production with other management functions, Interdepartmental relationship, Production operation strategies; **New Product Design:** Need, characteristics of phases of product life cycle, Product characteristics analysis, Market, functional, operational, quality, reliability, ergonomics, Economic consideration, FMECA, QFD; **Production Function:** Process design frame work, Work station, Line balancing, Different techniques, Batch Production, Minimum cost, Maximum profit, Production range, Process planning - Factors, steps, Selection of technology, Selection of equipment, Flow design. **Applications:** Application of Quantitative techniques for production decision Simulation, Sequencing, Queuing; **Capacity Planning:** Definition and basic concepts, Long term and short term capacity strategies, Aggregate planning - strategies and guidelines, LP approach to aggregate planning, MPS; **Plant Maintenance:** Principles, need, policies and objectives, Types of maintenance, Reliability and life testing, TPM; **Capital Investment Decisions:** Concept, Types, Concept of time value of money, Evaluation techniques, Replacement Analysis – Concept, Types, Evaluation Techniques.

Essential Readings:

1. Adam E E, RJ Ebert, ***Production and Operation Management,*** Prentice Hall.
2. Englewood Cliff, N J Riggs. J L, ***Production System, Planning, Analysis and Control,*** John Weily and sons, New York.
3. Martand Telsang, ***Industrial Engineering and Production Management***, S Chand & Co, New Delhi.
4. Buffa. E S, ***Modern Production and Operation Management***, Willey, New Delhi.
5. Barry Shore, ***Operation Management***, McGraw Hill Book Company, New York.
6. Samuel Eilon, ***Production Planning and Control***.

Supplementary Readings:

1. Joseph Monks, ***Operation Management Theory and Problems***, McGraw Hill Book Company, New York.
2. James Dilworth, ***Production and Operation Management***, McGraw Hill Book Company, New York.
3. Prasanna Chandra, Project Appraisal.

ID 232 ENGINEERING MATERIALS & HEAT TREATMENT PROCESSES 4 Credits [3-1-0]

Material classification: Classes of engineering materials, engineering requirement of materials, selection of materials, Mechanical, Thermal & Electrical properties of Materials and their measurement; **Structure And Imperfections in Crystals:** BSS, FCC and HCP structure, unit cell, crystallographic planes and directions, miler indices, crystal imperfections, point, line, planar and volume defects – Grain size, ASTM grain size number; **Constitution of Alloys and Phase Diagrams:** Constitution of alloys, solid solutions, substitutional and interstistial, phase diagrams, Isomorphous, eutectic, peritectic, eutectoid and peritectroid reactions, Iron carbide equilibrium diagram, Classification of steel and cast iron microstructure, properties and applications; **Heat Treatment:** Definition – Full annealing, stress relief, recrystallization and spheroidizing – normalizing, hardening and tempering of steel, Isothermal transformation diagrams – cooling curves superimposed on I. T. diagram CCR – Hardenability, Jominy end quench test – Austempering, martempering – case hardening, carburizing, nitriding, cyaniding, carbonitriding – Flame and Induction hardening; **Composites and Advanced Materials:** Ferrous material – Classification of steel and cast iron microstructure, properties and applications. Effect of alloying additions on steel (Mn, Sl, Cr, Mo, V TI & W) – stainless and tool steels – HSLA – maraging steels – Gray, White, malleable, spheroidal – Graphite – alloy cast irons. Non-ferrous materials – Copper, Aluminium, Nickel, Magnesium, Titanium, Lead, Tin alloys. Their composition, properties and applications. Non-metallic materials – Introduction to polymers, Composites and Ceramics; Elemental and compound semiconductors. Intrinsic and extrinsic semiconductors – properties; Nanophase materials – Shape Memory Alloys, Superconductivity, Metallic glasses.

Essential Readings:

1. S. K. Hazra Choudhury, ***Material Science & Processes***
2. O. P. Khanna, ***A Textbook of Material Science and Metallurgy***
3. William D Callister Jr, ***Material Science and Engineering***, John Wiley and Sons, New York, 2007.
4. Raghavan V, ***Material Science and Engineering – A First Course***, Prentice Hall of India, New Delhi, 2001.

Supplementary Readings:

1. Vamblack, ***Material Science***

ID 311	MECHANISMS, DESIGN & ANALYSIS	4 Credits [3-1-0]

Mechanisms: Lower & Higher Pairs, Degrees Of Freedom, Types Of Mechanisms, Their Inversions & Applications, Spatial Linkages, Determination Of Velocities & Accelerations Using Graphical & Analytical Techniques, Corioli's Components Of Accelerations, Cam Follower Systems, Cam Profiles, Cam Dynamics, Types Of Gearing & Gear Trains, Design Of Gears, Analytical Procedure For Synthesis Of Four Bar Mechanisms, Dynamic Force Analysis Of Mechanisms, Analytical & Graphical Techniques, Dynamic Motion Analysis, Flywheels, Balancing Of Rotors & Multi Cylinder Reciprocating Machines.

Essential Readings:

1. S S Rattan, ***Theory Of Machines***, TMH, 3rd edition, ISBN-10: 0-07-017477-X, 2009
2. Ghosh & Mallik, ***Theory Of Mechanisms & Machines***, Publisher: Affiliated East-west Press Pvt Ltd., ISBN: 8185938938,

ID 313	PRODUCT DESIGN - I	4 Credits [3-1-0]

Introduction: Definition Of Product Design, Design By Evolution & Design By Innovation, Essential Factors, Morphology Of Design, Primary Design Phases And Flow Charting, Product Strategies & Analysis, Standardization, Industrial Design Oranisation, Role Of Aesthetics In Product Design, Functional Design Practice, Strength, Stiffeners And Rigidity Considerations In Product Design, Review Of Production Processes, Primary, Machining & Nontraditional Machining Processes, Manufacturing Requirements In Design Of Machine Components, Design For Forging, Pressed Components, Casting & Machining, Designing With Plastics, Rubber, Ceramics & Wood, Economic Factor Effecting Design, Product Value, Design For Safety, Reliability And Environmental Considerations, Economic Analysis, Human Considerations In Product Design, Anthropometry, Design Of Control And Displays, Value Analysis & Engineering, Job Plans & Value Analysis Tests, Modern Approaches To Product Design, Concurrent Design.

Essential Readings:

1. Chitale & Gupta, ***Product Design & Manufacturing***, PHI, 3rd edition, ISBN-10: 8120326369, 2005.
2. Ulrich & Epinger, ***Product Design And Development***; T M H, ISBN-10: 007229647X, 2005.

ID 314	COMPUTER-AIDED DESIGN & MANUFACTURING	4 Credits [3-1-0]

Introduction - Definition of CAD/CAM, product cycle, automation, CPU, types of memory, input/output devices, data presentation, data and file structures, data base design, design work station, graphics terminal, operating devices, plotters and other output devices, CPU secondary storage, Turnkey CAD system, selection criteria, evaluation of alternative systems; Geometric Modeling Techniques - wireframe, surface and solid modeling, Geometric transformations, Graphics standards; CAM - Introduction to Numerical Control (NC) technology, current status of NC, Influence of NC in design & manufacturing, Computer aided NC programming in APT language, elements of APT language, APT vocabulary, symbols, numbers and scalars, punctuation, definition, statement labels, notations for APT statement format, statements defining point, line, circle, vector, planes and curves, point to point motion, cutter contouring motion, starting, terminating, roughing, finishing, problems.

Essential Readings:

1. Groover & Zimmers, ***CAD-CAM*** – Pearson, ISBN: 978-81-758-465, 2008
2. PN Rao, ***CAD/CAM***- Mc Graw Hill, ISBN: 007-068-19-37, 2010
3. K. Lalit Narayan et al, ***Computer Aided Design & Manufacturing*** PHI, ISBN: 978-81203-3342-0, 2008
4. Ibrahim Zeid, ***Mastering CAD/CAM***, Special Indian Edition 2007, Tata McGraw-Hill Publishing Company Ltd., New Delhi.

ID 330 MATERIALS MANAGEMENT 3 Credits [3-0-0]

Introduction : scope of materials management – primary and secondary, objectives – integrated materials management – relation with other functional areas of organization.; Organizing for materials management – basis for forming organizations – conventional and modern approaches to organizing materials management. Materials identification – classifying of materials – codification of materials – standardization – simplification and variety reduction of materials.; Inventory control – techniques – FSN, VED, ABC – working capital management with reference to inventory; Management of stores – location – different types of stores – methods of storing – safety and security of materials – stores equipment – materials handling equipment – factors affecting materials handling; Stores issues and receipts – procedures – forms and policies in stores transactions – stores accounting – stores organization – materials safety and security; Management of surplus obsolete and scrap materials – reasons for accumulation of surplus obsolete and scrap materials – methods of disposal – regulations and procedures; Purchasing – planning purchasing materials – norms of vendor rating – CEI; methodology, Japanese industry – selection and development – purchasing; procedures and methods – legal aspects – insurance of materials – supply; management – sources of supply – out sourcing; Sub contracting – reasons for subcontracting – criteria for selecting sub contractors – rating – factors affecting subcontract rate fixing – internal and; external subcontract.

Essential Readings:

1. A. K. Datta, ***Integrated materials management***, PHI.
2. Dobbler, Burt D. N, ***Purchasing and Supply Management,*** TMI, 7/e, 2004

Supplementary Readings:

1. P Gopalakrishnan – ***Materials Management*** –PHI, 2002
2. Leenders Fearon – ***Purchasing And Materials Management*** –Universal Book Stall
3. K S Menon – ***Purchasing And Inventory Control*** –Wheeler Publishers
4. Varma M M – ***Materials Management*** –Sultan Chand And Sons

ID 332 VALUE ENGINEERING 3 Credits [3-0-0]

An Overview: Definition, principle of value engineering, VE recommendations, programmes advantages. The role of value value engineer; **Approach of Function**: Evaluation of function, determining function, classifying function, evaluation of costs, evaluation of worth, determining worth, evaluation of value; **VE Job Plan**: Introduction, orientation, information phase, speculation phase, analysis phase, development phase, implementation phase, and follow up phase; **Selection and Evaluation of VE Projects**: Projects selection, methods, value standards, application of VE methodology; **Staffing For VE**: General, functional concept, centralization, decentralization of VE staff, training: Industrial training - conduct of training, continuous training and cost of training; **Fast Diagramming**: Value decision, decision process, queuing theory and Monte Carlo Method, cost models, life cycle costs; **VE Level of Effort**: VE team, co-ordinator, designer, different services, definitions, construction management contracts, value engineering case studies; **Case Study**: Case studies related to human resource, manufacturing and marketing field.

Essential Readings:

1. Tufty Herald G, ***Compendium on Value Engineering***, The Indo American Society, First Edition, 1983.
2. J. H Janson, ***Value Engineering in Manufacturing,*** Prentice Hall, New Jersey, 1967.

Supplementary Readings:

1. Miles L D, ***Techniques of Value Engineering and Analysis***, McGraw Hill, Second Edition, New York, 1972.
2. Khanna O P, ***Industrial Engineering and Management***, Dhanpat Rai and Sons, New Delhi, 1993.
3. Kumar S, Singh R K and Jha J K (Ed), ***Value Engineering***, Narosa Publishing House, 2005.

ID 337 MANUFACTURING SCIENCE 3 Credits [3-0-0]

Prerequisites: Work Shop Practice I & II

Role of manufacturing process in product design, classification of processes; Casting process, pattern and mould, melting and pouring, solidification and cooling, removal and finishing, sand casting, comparisons of casting processes.; Metal forming, cold and hot working, rolling, forging, extrusion, drawing, deep drawing, punching and blanking, comparison of forming process.; Machining process, metal cutting, grinding and finishing operations, comparison.

Essential Readings:

1. G K Lal & Vijay Gupta, ***Fundamentals of design & manufacturing***, Narosa Publishers
2. Ulrich & Epinger, ***Product design & development***, TMH Publishers
3. Ghosh & Malik, Manufacturing Science, New Age Publishers.

ID 338	**PRODUCT DEVELOPMENT AND MANUFACTURING**	**3 Credits [3-0-0]**

Prerequisites: Work Shop Practice I & II

Unconventional machining, ultrasonic, electrochemical, laser beam, electro discharge machining, comparison, numerical examples.; Selection of manufacturing processes, manufacturing cost, production volume, manufacturing characteristics, material properties, shapes, sizes, dimensional accuracy and surface finish.; Product development, from concept to product designing for function, production, handling, use and maintenance; Design for manufacturability, designing for economical production, design considerations in sand casting, forging, machining, grinding and welding.; Integrated manufacturing.

Essential Readings:

1. G K Lal & Vijay Gupta, ***Fundamentals of design & manufacturing***, Narosa Publishers
2. Ulrich & Epinger, ***Product design & development***, TMH Publishers
3. Ghosh & Malik, Manufacturing Science, New Age Publishers.

ID 339	**GROUP TECHNOLOGY AND FMS**	**3 Credits [3-0-0]**

GROUP TECHNOLOGY : Introduction, need of G. T. Part families, Methods for developing part families; Basic type of Codes – hierarchical codes, Attribute code, Hybrid code, selecting a coding system, Developing a coding system in an industry, examples of coding systems, MICLASS, OPITZ, CODE systems; Facility Design using, GT, Economic modeling in GT environment – production planning cost model, Economics of GT, Application of GT for design retrieval, CAPP, NIC, MR and FMS; INTRODUCTION : Manufacturing Automation, Definition and types of FMS, Architecture of FMS, Workpiece flow in FMS, Performance measures of FMS; WORK STATION : CNC Machines, Machine Centres, Inspection Stations; AUTOMATED MATERIAL HANDLING : Function of MHS, Types of Material handling equipment, Conveyor systems, AGVs, Industrial Robots; AUTOMATED STORAGE SYSTEMS: Characteristics of Storage Systems; COMPUTER CONTROL SYSTEM OF FMS : Functions of Computer, Control system architecture, Factory level, Cell level control systems, Equipment control systems, Factory communications, Local area networks, Data files and system reports; Concept of CIM – historical background –- CIM hardware – CIM software – CIM wheel - introduction to intelligent manufacturing system – virtual machining.

Essential Readings:

1. Mikell P. Groover, ***Automation, Production Systems, and Computer-Integrated Manufacturing***, 2nd Edition, Reprint 2002, Pearson Education Asia.

Supplementary Readings:

1. N. Viswanadham, Y. Narahari, ***Performance Modeling of Automated Manufacturing Systems***.
2. B. Henderson, Wolfe, ***Computer Integrated Design and Manufacturing***.
3. Groover and Zimmers, ***CAD/CAM***.
4. Y. Koren, ***Computer Control of Manufacturing Systems***, International Edition 1983, McGraw Hill Book Co.

ID 352	**INDUSTRIAL MECHATRONICS**	**4 Credits [3-1-0]**

Introduction : Introduction to Mechatronics, need and applications, elements of mechatronic systems, role of mechatronics in automation, manufacturing and product development; **Sensors and Feedback Devices :** Importance of sensors in Mechatronics, Static and Dynamic characteristics of sensors, errors and output impedance of sensors, transducers for measurement of displacement, strain, position, velocity, noise, flow, pressure, temperature, humidity, vibration, liquid level, vision sensors; **Control Elements and Actuators :** On/off push buttons, control relays, thermal over load relays, contactors, selector switches, solid state switches. Mechanical actuators – types of motion, gear trains, belt and chain drives, screw rods. Electrical actuators, solenoids, DC drives and AC variable frequency drives, AC and DC motors, servomotors, stepper motors, linear motors. Hydraulic and Pneumatic controls, functional diagram - control valves, cylinders and hydro motors; **Computational Elements and Controllers :** Basic concepts of control systems – open loop, closed loop, semi closed loop control system, block and functional diagrams controllers for robotics and CNC, linear and rotary encoders, timers, counters, microprocessors and microcontrollers: introduction, programming and applications, introduction to PLC, simple programs for process control application based on relay ladder logic-Supervisory Control and Data Acquisition Systems (SCADA) and Human Machine Interface (HMI); **Interfacing Systems :** Introduction to interfacing of different hard wares in industry, need for networks in industrial plants, hierarchy and structure of networking, RS 232 based network, Ethernet, TCP/IP, MAP/TOP; **Application of Mechatronic Systems :** Introduction to factory automation and integration, design of simple Mechatronics systems, Case studies based on the application of mechatronics in manufacturing, autotronics, bionics and avionics.

Essential Readings:

1. S Cetinkunt, ***Mechatronics***, John wiley, 2007.
2. J Stenersons, ***Fundamentals of Programmable Logic Controllers Sensors and Communications***, Prentice Hall, 2004.

Supplementary Readings:

1. A. Kuttan K K, ***Introduction to Mechatronics***, Oxford University Press, 2007.
2. D. G. Alciatore and M. B. Histand, ***Introduction to Mechatronics and Measurement systems***, McGraw Hill, NY, 2007.
3. Bolton W, ***Mechatronics***, Pearson Education Asia, New Delhi, 2004.
4. HMT, ***Mechatronics***, Tata McGraw Hill Publishers, New Delhi, 1998.
5. S. Soloman, C***omputer Control of Manufacturing Systems***, McGraw Hill, New York, 1983.
6. K. J Ayala, ***8051 Microcontroller, Architecture, Programming and Applications***, Penram International, India, 1996.

ID 357	INDUSTRIAL AUTOMATION	3 Credits [3-0-0]

Architecture of Industrial Automation Systems, Measurement Systems Characteristics, Motion Sensing, Signal Conditioning, Flow Measurement, PID Control Tuning, Time Delay Systems and Inverse Response Systems, Hydraulic Control Systems, DC Motor Drives, Step Motor Drives BLDC Drives.

Essential Readings:

Supplementary Readings:

ID 359	INSTRUMENTATION AND CONTROL	3 Credits [3-0-0]

MEASUREMENT OF FORCE, TORQUE AND VELOCITY : Electric balance – Different types of load cells – Magnets – Elastic load cells - Strain gauge load cell – Different methods of torque measurement – Strain gauge, relative regular twist – Speed measurement – Revolution counter – Capacitive tacho-drag cup type tacho – D. C and A. C tacho generators – Stroboscope; MEASUREMENT OF ACCELERATION, VIBRATION, DENSITY AND VISCOSITY: Accelerometers – LVDT, piezoelectric, strain gauge and variable reluctance type accelerometers – Mechanical type vibration instruments – Seismic instrument as an accelerometer and vibrometer – Calibration of vibration pick-ups – Units of density, specific gravity and viscosity used in industries – Baume scale, API scale – Pressure head type densitometer – Float type densitometer – Ultrasonic densitometer – Bridge type gas densitometer – Viscosity terms – Saybolt viscometer – Rotameter type; PRESSURE MEASUREMENT: Units of pressure - Manometers – Different types – Elastic type pressure gauges – Bourdon type bellows – Diaphragms – Electrical methods – Elastic elements with LVDT and strain gauges – Capacitive type pressure gauge – Piezo resistive pressure sensor – Resonator pressure sensor – Measurement of vacuum – McLeod gauge – Thermal conductivity gauges – Ionization gauge, cold cathode and hot cathode types – Testing and calibration of pressure gauges – Dead weight tester; TEMPERATURE MEASUREMENT: Definitions and standards – Primary and secondary fixed points – Calibration of thermometer, different types of filled in system thermometer – Sources of errors in filled in systems and their compensation – Bimetallic thermometers – Electrical methods of temperature measurement – Signal conditioning of industrial RTDs and their characteristics – Three lead and four lead RTDs; THERMOCOUPLES AND PYROMETERS: Thermocouples – Laws of thermocouple – Fabrication of industrial thermocouples – Signal conditioning of thermocouples output – Thermal block reference functions – Commercial circuits for cold junction compensation – Response of thermocouple – Special techniques for measuring high temperature using thermocouples – Radiation methods of temperature measurement – Radiation fundamentals – Total radiation & selective radiation pyrometers – Optical pyrometer – Two colour radiation pyrometers.

Essential Readings:

1. E. O. Doebelin, ***Measurement Systems – Application and Design***, Tata McGraw Hill publishing company, 2003.
2. R. K. Jain, ***Mechanical and Industrial Measurements***, Khanna Publishers, New Delhi, 1999.

Supplementary Readings:

1. D. Patranabis, ***Principles of Industrial Instrumentation***, Tata McGraw Hill Publishing Company Ltd, 1996.

2. A. K. Sawhney and P. Sawhney, ***A Course on Mechanical Measurements, Instrumentation and Control***, Dhanpath Rai and Co, 2004.
3. B. C. Nakra & K. K. Chaudary, ***Instrumentation Measurement & Analysis***, Tata McGraw Hill Publishing Ltd, 2004.
4. S. K. Singh, ***Industrial Instrumentation and Control***, Tata McGraw Hill, 2003.
5. D. P. Eckman, ***Industrial Instrumentation***, Wiley Eastern Ltd.

ID 411	PRODUCT DESIGN – II	4 Credits [3-1-0]

Product Characteristics, Product Classification, Qualities Of Product Designers And Developers, The Purpose And Process Of Product Design, Design Requirements and Factors, The Structure Of Design Process, Identification And Analysis of need, Raw Data, Customers, Standardization, Documenting and Interpretation.; Origination of Design Concepts, Creative Attitude, Creative Process, Creativity By Analogy, Search For Design Concepts, Morphological Analysis, Decision Making In Designing.; Physical Reliability, Economic And Financial Feasibility, Design Quality.

Essential Readings:

1. Ulrich & Epinger, ***Product Design And Development***; T M H, ISBN-10: 007229647X, 2005.
2. Otto, ***Product Design***, fourth impression 2009,, Pearson, ISBN: 8177588214
3. Roozenburg & J. Eekels, ***Product Design, Fundamentals and Methods***, Willey publications, 2008.

ID 414	ERGONOMIC AND AESTHETIC DESIGN	3 Credits [3-0-0]

Introduction to man machine systems and ergonomics, Human factors in design and engineering, Needs of ergonomics and aesthetic design, Physiological aspects of work, Work measurement through physiological tests, Work physiology, Paced and unpaced work performance, Data logging, data collection, data reduction and analysis techniques, Gross human anatomy, Anthropometry, Bio mechanics, muscle strength and exertion potential of different limbs, Work capacity, Environmental effects, exercises for evaluation of pastural form and work spaces, Environmental conditions including temperature, illumination, noise and vibration. Perception and information processing, design of displays, hand control, typography, and readability, layout and composition, Exercises in evaluation of human response to product interface, product safety and product liability, Design consideration for appearance, colour, texture and forms.

Essential Readings:

1. D. C. Alexander, ***Applied Ergonomics***, Taylor & Francis, 2005, ISBN- O-203-30259-1
2. Jan Dul, ***Ergonomics for Beginners***, Taylor & Francis, 2008
3. David Pye, ***The Nature & Aesthetics of Design***, Cambium Press, 1999.

ID 416	THERMAL CONSIDERATIONS IN DESIGN	3 Credits [3-0-0]

Prerequisites: ME 250

Introduction to computational methods in thermal engineering & fluid mechanics, Thermal Stresses: formulation of thermo elastic problems, basic equations, displacement and stress formulation in rectangular plate and free plate with temperature variation through thickness, thermal stresses in thick cylinders, circular discs, spheres and beams with arbitrary cross section.; Thermal Design objectives, principles of thermal design, system simulation and optimization, Modelling of static and dynamic systems, Steady state and dynamic behaviour of the thermal systems, Design considerations of instruments, heat exchangers and refrigeration systems.

Essential Readings:

1. L S Srinath, ***Advanced mechanics of solids***- TMH, ISBN: 0070139881, 2009
2. Kakac***, Heat exchangers: Thermal and Hydraulic Fundamentals and Design***- ISBN: 0070332843 / 0-07-033284-3
3. Barron & Randall, ***Design for Thermal Stresses***, ISBN-10: 0-470-62769-7 John Wiley & Sons, 2011.

ID 418	RAPID PRODUCT DEVELOPMENT & TECHNIQUES	3 Credits [3-0-0]

Overview of Rapid Product Development: Product Developing Cycle, Components of RPD, Classification of manufacturing processes; Preprocessing: Solid Modeling, Data exchange formats, STL file format, RP Preprocessing; Rapid Prototyping (RP): Introduction to RP, Need of RP; Basic Principles of RP, Steps in RP, Process chain in RP in integrated CAD-CAM environment, Advantages of RP, Classifications of different RP techniques, Selection of RP processes, Issues in RP, Emerging trends; RP Techniques: Solid RP, liquid RP techniques and Powder RP Techniques – Process Technology and Comparative study of Selective laser sintering, Selective powder binding, etc; Rapid Tooling (RT): Introduction to RT, Indirect RT processes – silicon rubber molding, epoxy tooling, spray metal tooling and investment casting. Direct RT processes – laminated tooling, powder metallurgy based technologies, welding based technologies, direct pattern making, emerging trends in RT; Reverse Engineering: Geometric data acquisition, 3D reconstruction. Applications and case studies: Engineering applications, Medical applications; Special Topic on RP, Programming in RP, Modelling, Slicing, Internal Hatching, Surface Skin Fills, Support Structure. Overview of the algorithms for RP & T and Reverse Engineering.

Essential Readings:

1. Kai, C. C. and Fai L. H., ***Rapid Prototyping: Principles and Applications in Manufacturing***, John Wiley and sons, 1997.
2. Jacobs, P. F., ***Rapid Prototyping and Manufacturing***, SME/ASME, 1996
3. Zeid, I., ***CAD/CAM – Theory and Practice***, TMH, 2006.
4. Faux, D. and Pratt, M. J., ***Computational Geometry for Design and Manufacture***, John Wiley and Sons, 1979.

ID 430	PROJECT MANAGEMENT	3 Credits [3-0-0]

Project Management Concepts: Concept and characteristics of a project, importance of project management, types of project, project organizational structure, projectlifecycle, Statement of Work, Work Breakdown Structure; Project Planning: Project Planning and Scheduling techniques: developing the project network USING CPM/PERT, constructing network diagram, AON basics, Forward Pass and backward pass, Limitations of CPM/PERT, Precedence Diagramming Method, constructing diagram and computations using precedence diagramming method, PERT/CPM simulation, reducingprojectduration; Resource Scheduling: Resource allocation method, splitting and multitasking, Multi project resources scheduling; Critical ChainScheduling: Concept of critical chain scheduling; critical chain scheduling method, application of Critical chain scheduling and limitations; ProjectQuality Management : Concept of project quality, responsibility for quality in projects, quality management at different stages of project, tools and techniques, Quality Management Systems, TQM in projects; ProjectperformanceMeasurement and Control: Monitor and assess project performance, schedule, and cost. EarnedvalueManagement, performance measurement. methods to monitor, evaluate, and control planned cost and scheduleperformance; Project Closure/ Termination: Meaning of closure/ termination, project audit process, termination steps, final closure; ManagingProjectTeams: Team development process, team building process, stages in developing a high performance project team, project team pitfalls; IT in Projects: Overview of types of softwares for projects, major features of softwares like MS Project, criterion for software selection.

Essential Readings:

1. C. F Gray, E. W Larson, ***Project Management-The Managerial Process,*** Tata Mcgraw-Hill Publishing Co Ltd.
2. J. Meredith, S. J. Mantel Jr., ***Project Management- A Managerial Approach,*** John Wiley and Sons.
3. J. M Nicholas, ***Project Management For Business And Technology,*** Prentice Hall of India Pvt Ltd.
4. J. P Lewis, ***Project Planning, Scheduling And Control,*** Tata McGraw-Hill Publishing Co Ltd.

ID 435	MEMS AND NEMS	3 Credits [3-0-0]

Module 01: Historical Background: Silicon Pressure sensors, Micromachining, Micro Electro Mechanical Systems. Microfabrication and Micromachining: Integrated Circuit Processes. Potential of MEMS in industry; **Module 02 :** Bulk Micromachining : Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA); **Module 03** : Physical Microsensors: Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples: Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical and Biosensors. Microactuators: Electromagnetic and Thermal microactuation, Mechanical design of microactuators, Microactuator examples, microvalves, micropumps, micromotors Microactuator systems: Success Stories, Ink-Jet printer heads, Micro-mirror TV Projector; **Module 04** : Microstereolithography (MSL) for 3D fabrication, Two photon MSL, Dynamic mask MSL, scanning systems, Optomechatronics system for MSL. Ceramic and Metal Microstereolithography; **Module 05** : Ceramic and Metal Microstereolithography. Scattering of light by small particles. Effect of particle properties on accuracy and resolution of component in Ceramic and Metal MSL. Monte carlo ray tracing method. Nanolithography; **Module 06** : Surface Micromaching: One or two sacrificial layer processes, Surface micromachining requirements, Polysilicon surface micromachining, Other compatible materials, Silicon Dioxide, Silicon, Micromotors, Gear trains, Mechanisms. Characterisation of MEMS devices.

Essential Readings:

1. Vijay Vardan, ***MEMS***, Wiley Publication.
2. Tai- Ran Hsu, ***MEMS and Microsytems Design and Manufacture***, Tata McGraw Hill.
3. Nitaigour Mahalik, ***MEMS***, Tata McGraw Hill.
4. Rai Chaoudhary, ***MEMS and MOEMS Technology and Applications***, PHI Learning.

Supplementary Readings:

1. Stephen D. Senturia, ***Microsystem Design***, Kluwer Academic Publishers,
2. Marc Madou, ***Fundamentals of Microfabrication***, CRC Press
3. Kovacs, ***Micromachine Transducers Sourcebook***, WCB McGraw-Hill, Boston
4. M-H. Bao, Elsevier, ***Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes***, New York, 2000.

ID 437 INDUSTRIAL ENGINEERING & OPERATION RESEARCH 3 Credits [3-0-0]

Introduction : Evolution of industrial engineering – fields and functions; industrial productivity – types, measurement; work systems engineering – recording tools and techniques, motion study, PMTS, therbligs, work sampling, work measurement, rating systems, ergonomics; **Plant Design :** Plant location – decision analysis; plant layout –types, characteristics, design techniques-systematic layout planning (SLP), computerized relative allocation of facilities technique (CRAFT); material handling principles – equipments; introduction to line balancing; **Production Planning and Control :** Functions - demand management – forecasting techniqyes, forecast errors – sources; scheduling – basics – single machine scheduling; flow shop scheduling; job shop scheduling, heuristic procedures; priority dispatching rules; **Operations Research :** Origin, scope, areas of application; mathematical modeling and solving a problem; linear programming – problem formulation, deriving the solution – graphical, simplex methods; **Transportational Model :** Formulation, solution – northwest corner, Vogel's, stepping stone, MODI methods; degeneracy; Assignment models – Hungarian algorithm; Sequencing models – processing 'n' jobs through two machines and three machines, processing two job through 'n' machines; **Inventory Models :** Classification of fixed order quantity models, deterministic demand models – types, inventory models with probabilistic demand, price breaks, quantity discount, safety stocks, selective inventory control techniques; **Queuing Models :** Elements, operating characteristics; single channel queuing theory – models for arrival and service times; models for multichannel queuing theory.

Essential Readings:

1. F. S Hillier and G. J Liberman, ***Introduction to Operations Research***, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2006.

Supplementary Readings:

1. P K Gupta and D S Hira, ***Operations Research***, S Chand & Co., New Delhi, 2008.
2. R Paneerselvam, ***Production and Operations Management***, Prentice Hall of India (P) Ltd., 2007.
3. H. A Taha, ***Operations Research : An Introduction***, Prentice Hall of India, 2002.
4. E. S Buffa, ***Modern Production / Operations Management***, Wiley Eastern, 1991.
5. M. Telsang, ***Industrial Engineering and Production Management***, S. Chand and Co Ltd.
6. O. P. Khanna, ***Industrial Engineering and Management***, Dhanpat Rai Pub.

ID 439 DESIGN OF PRODUCTION TOOLING 3 Credits [3-0-0]

Tool Design : Tool design objectives - tool design in manufacturing, planning the design, challenges to the tool designer, production devices - Inspection devices; **Principles of Supporting and Locating Elements :** Referencing, basic rules of locating, planes of movement, locating from a flat surface, locating from a internal diameter, locating from a external diameter, locating from extemal profile, ejectors; principles of clamping and work holding - principles of work holders, basic rules of clamping, types of clamps, chucks and vises, non mechanical clamping, clamping accessories. Materials used in Jigs and Fixtures; **Design of Jigs :** Drill bushes - different types of jigs-plate latch, channel, box, post, angle plate, angular post, turnover, pot jigs-Automatic drill jigs-Rack and pinion operated, air operated jigs components, design and development of jigs for given components, cost estimation; **Design of Fixtures :** General principles of boring, lathe, milling and broaching fixtures- Grinding fixtures, assembly, Inspection and welding fixtures- Modular fixtures. Design and development of fixtures for given component. Fixtures for CNC Machining centres; chucks for CNC lathes - power operated 3 jaw chucks, closed centre, open centre, centrifugal force compensated, indexing, diaphragm, face driving, face clamping, pull back! ball lock; **Power Presses :** Press working terminology, different types of presses, press brakes, shearing machines, CNC Turret punch and bending, press accessories, computation of capacities and tonnage requirements; **Design of Progressive and Compound Dies:** Design and development of progressive and compound dies for blanking and piercing operations. Die block-die shoe. Bolster plate-punch plate-punch holder-guide pins and bushes, strippers, knockouts, stops, pilots, selection of standard die sets strip layout-strip layout calculations; **Manufacturing of Punches and Dies:** CNC WIRE CUT, EDM; **Forming Dies:** Drawing die, stamping die, forging die; **Design of Plastic Injection Molding Dies:** Introduction to plastics, various plastic processing process and machines, two plate injection mold assembly design, design of gates, runners, ejectors, under cut molds, finger cam design, three plate injection mold, hot / runner less mold, mold materials, mold manufacturing, polishing.

Essential Readings:

1. Donaldson C, ***Tool Design***, Tata McGraw Hill, New Delhi, 2003.

2. R G W PYE, ***Injection Mold Design***, Longman, 1991.

Supplementary Readings:

1. Edward G Hoffman, ***Jigs and Fixture Design***, Thomson - Delmar Learning, Singapore 2004.
2. Joshi P H, ***Jigs and Fixtures***, Tata McGraw Hill Publishing Company Limited, New Delhi 2004.
3. Hiram E Grant, ***Jigs and Fixture,*** Tata McGraw Hill, New Delhi, 2003.
4. ***Tool Design***, SME, 2003.
5. Kempster, ***Jigs and Fixtures Design***, The English Language Book Society, 1998.
6. ASTME, ***Fundamentals of Tool Design***, Prentice Hall, 1987.

ID 446 QUALITY CONTROL TECHNIQUES AND RELIABILITY 3 Credits [3-0-0]

Introduction and Process Control For Variables : Introduction, definition of quality, basic concept of quality, definition of SQC, benefits and limitation of SQC, Quality assurance, Quality cost-Variation in process- factors – process capability – process capability studies and simple problems – Theory of control chart- uses of control chart – Control chart for variables – X chart, R chart and ? chart; **Process Control For Attributes:** Control chart for attributes –control chart for proportion or fraction defectives – p chart and np chart – control chart for defects – C and U charts, State of control and process out of control identification in charts; **Acceptance Sampling:** Lot by lot sampling – types – probability of acceptance in single, double, multiple sampling techniques – O. C. curves – producer's Risk and consumer's Risk. AQL, LTPD, AOQL concepts-standard sampling plans for AQL and LTPD- uses of standard sampling plans. **Life Testing – Reliability:** Life testing – Objective – failure data analysis, Mean failure rate, mean time to failure, mean time between failure, hazard rate, system reliability, series, parallel and mixed configuration – simple problems. Maintainability and availability – simple problems. Acceptance sampling based on reliability test – O. C Curves. **Quality and Reliablity:** Reliability improvements – techniques- use of Pareto analysis – design for reliability – redundancy unit and standby redundancy – Optimization in reliability – Product design – Product analysis – Product development – Product life cycles.

Essential Readings:

1. Grant, Eugene. L ***Statistical Quality Control***, McGraw-Hill, 1996.
2. L. S. Srinath, ***Reliability Engineering***, Affiliated East west press, 1991.

Supplementary Readings:

1. Monohar Mahajan, ***Statistical Quality Control***, Dhanpat Rai & Sons, 2001.
2. R. C. Gupta, ***Statistical Quality Control***, Khanna Publishers, 1997.
3. Besterfield D. H., ***Quality Control***, Prentice Hall, 1993.
4. Sharma S. C., ***Inspection Quality Control and Reliability***, Khanna Publishers, 1998.
5. Connor, P. D. T. O., ***Practical Reliability Engineering***, John Wiley, 1993.

ID 456 INDUSTRIAL ROBOTICS 3 Credits [3-0-0]

INTRODUCTION: Fundamental concepts of robotics, history, present status and future trends, robotics and automation, laws of robotics, robot definition, robotics systems and robot anatomy, specification of robots, resolution, repeatability and accuracy of a manipulator; MANIPULATORS: Robot drive mechanisms, hydraulic, electric, pneumatic drives, mechanical transmission method, rotary-to-rotary motion conversion, rotary-to-linear motion conversion, robot drives, power transmission systems and control, control of actuators in robotic mechanisms; END EFFECTORS: Unilateral grippers, bilateral grippers, multi-lateral grippers, mechanical grippers, types of gripper mechanism, remote centered compliance devices; TRANSFORMATION AND KINEMATICS: Homogeneous coordinates, homogeneous transformation and manipulator, forward solution, inverse solution, motion generation, Jacobian control; SENSORS: Internal state sensors, external state sensors, sensory devices, non-optical position sensors, optical. Position sensors, velocity sensors, proximity sensors, contact and non-contact type, touch and slip sensors, force and torque sensors; MACHINE VISION: Robot vision systems, imaging components, image representation, hardware aspects, picture coding, object recognition and categorization, visual inspection, software considerations, applications, commercial robotic vision systems; PROGRAMMING AND APPLICATIONS: Computational elements in robotic applications, robot programming - sample programs, path planning, robot's computer system, capabilities of robots, robotic applications, obstacle avoidance, AI and robotics, robotics in India, the future of robotics.

Essential Readings:

1. Richaerd D Klafter, Thomas Achmielewski and Mickael Negin, ***Robotic Engineering - An Integrated Approach,*** Prentice Hall

India, New Delhi, 2001.
2. Mikell P Groover, ***Industrial Robotics - Technology, Programming and Applications***, McGraw Hill, 1986.

Supplementary Readings:

1. James A Rehg, ***Introduction to Robotics in CIM Systems***, Prentice Hall of India, 2002.
2. Deb S R, ***Robotics Technology and Flexible Automation***, Tata McGraw Hill, New Delhi, 1994.
3. Janaki Raman P A, ***Robotics and Image Processing***, Tata McGraw Hill, 1991.

ID 458	DESIGN OF MANUFACTURE AND ASSEMBLY	3 Credits [3-0-0]

DFM Approach, Selection and Substitution of Materials: DFM approach, DFM guidelines, standardisation, group technology, value engineering, comparison of materials on cost basis, design for assembly, DFA index, Poka - Yoke principle; 60' concept; **Geometric Dimensioning and Tolerancing :** Introduction to GD & T, ASME Y 14. 5 standard. Examples for application of geometric tolerances. True Position Theory - Comparison between co-ordinate and convention method of feature location, tolerancing and true position tolerancing, virtual size concept, floating and fixed fasteners, projected tolerance zone, zero true position tolerance, functional gauges, paper layout gauging, compound assembly, examples; **Tolerance Analysis:** Process capability, process capability metrics, Cp, Cpk, cost aspects, feature tolerances, surface finish, review of relationship between attainable tolerance grades and different machining process, cumulative effect of tolerances, sure fit law, normal law and truncated normal law, obtainable tolerances in axial dimensions for various machining operations; **Selective Assembly:** Interchangeable and selective assembly, deciding the number of groups-model-I: group tolerances of mating parts equal; model-II: total and group tolerances of shaft, control of axial play-introducing secondary machining operations, laminated shims, examples; **Datum Systems:** Degrees of freedom, grouped datum systems-different types, two and three mutually perpendicular grouped datum planes, grouped datum system with spigot and recess, pin and hole, grouped datum system with spigot and recess pair and tongue-slot pair-computation of translational and rotational accuracy, geometric analysis and applications; **Form Design of Castings and Weldments:** Redesign of castings based on parting line considerations, minimising core requirements, redesigning cast members using weldments, use of welding symbols, design of weldments; **Tolerance Charting Technique:** Operation sequence for typical shaft type of components, preparation of process drawings for different operations, tolerance worksheets and centrality analysis, examples, design features to facilitate machining, datum features - functional and manufacturing, component design-machining considerations, redesign for manufacture, examples.

Essential Readings:

1. Harry Peck, ***Designing for Manufacture***, Pitman Publications, London, 1983.
2. Matousek R, ***Engineering Design - A Systematic Approach***, Blackie and Son Ltd., London, 1974.

Supplementary Readings:

1. Creveling C M, ***Tolerance Design - A Hand Book for Developing Optimal Specifications***, Addison Wesley Longman Inc., USA, 1997.
2. Mamboed M Farag, ***Material Selection for Engineering Design***, Prentice Hall, New Jersey, 1997.
3. Pahl G and Beitz W, ***Engineering Design-Systematic Approach***, Springer Verlag Pub., New York, 1996.
4. ***Poka-Yoke Improving Product Quality by Preventing Defects***, Productivity Press, New York, 1992.
5. Trucks HE, ***Design for Economic Production***, Society of Manufacturing Engineers, Michigan, 1987.
6. Spotts M F, ***Dimensioning and Tolerance for Quantity Production***, Prentice Hall Inc., New Jersey, 1983.
7. James G Bralla, ***Hand Book of Product Design for Manufacturing***, McGraw Hill Publications, New York, 1983.
8. Oliver R Wade, ***Tolerance Control in Design and Manufacturing***, Industrial Press Inc., New York, 1967.

DETAILED COURSE SYLLABUS
B. TECH. (FOOD PROCESS ENGINEERING)

A. CORE COURSES

FP 201	Food Microbiology	4 credits [3-1-0]

Objectives: To get in-depth knowledge of food borne microorganisms, their growth, and detection, control and food preservation

Syllabus:
Introduction: scope of food microbiology; Microorganisms important in food industry; Types of microorganisms, their importance in foods, classification of food borne bacteria, their morphology and distinguishing features with examples; Growth of microorganisms in foods; Intrinsic (pH, moisture content, redox potential, nutrient content, antimicrobial constituents and biological structures) and extrinsic factors (temp., RH, presence and concentration of gases) governing growth of microorganisms in food; Food spoilage: Chemical changes caused by microorganisms in foods (breakdown of proteins, carbohydrates, fats and other constituents during spoilage), specific microorganisms causing spoilage of milk and milk products, meat, fish, egg, cereals, fruits, vegetables and their processed products, quality defects in canned foods, sugar and confectionary products; Food fermentations: General description of fermenters, parts and their functions, different types of fermentations (static, submerged, agitated, batch, continuous). Microbial culture selection by screening methods and strain improvement. Starter cultures - definition, types, Fermentation - definition, types (acid, alcohol). Fermented foods - types, methods of manufacture for vinegar, ethyl alcohol, cheese, yoghurt, baker's yeast and traditional Indian foods; Microbial Foodborne Diseases: Introduction, types of microbial foodborne diseases (foodborne intoxications and foodborne infections), symptoms and prevention of some commonly occurring food borne diseases; Food Preservation: Principles of preservation, methods of food preservation – high temperature, low temperature, drying, radiation, chemical preservatives, bio-preservatives, hurdle technology, active packaging, novel processing technologies.

Recommended Books:

1. Food Microbiology, TMH, New Delhi *by* W C Frazier & D C Westhoff
2. Modern Food Microbiology, CBS Publication, New Delhi *by* J M Jay
3. Essentials of Food Microbiology, Arnold, London *by* John Garbutt
4. Microbiology,5th Ed., TMH, New Delhi *by* M J Pelczar, E C S Chan and Noel R Krieg
5. Microbiology of Safe Food, Blackwell Science, Oxford *by* S J Forsythe
6. Fundamentals of Food Microbiology AVI Publishing Co. Inc., Connecticut, USA *by* M L Fields
7. Microbiology of foods *by* J C Ayres, J O Mundt, W E Sandine, W H Freeman

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 201	Food Microbiology	✓	✓	✓	✓					✓			

FP 271	Engineering Properties of Biological Materials Laboratory	2 credits [1-0-2]

Objectives: To learn various engineering properties of biological materials.

Syllabus:

Determination of physical dimension and average particle size of food grains, Determination of bulk density, true density and porosity of grains, Determination of volume and specific gravity of fruits Determination of roundness and roundness ratio of biological materials, Determination of sphericity of biological materials, Determination of angle of repose of food grain samples, Determination of frictional properties of biological material, Determination of aerodynamic properties of biomaterial, To study the separating behaviour of a grain sample in a vertical wind tunnel (aspirator column), Determination of moisture content of sample by direct and in-direct methods, Measurement of (grain, fruit) hardness (Moh's hardness test), compressive strength, Determine flow parameters of Newtonian, Non Newtonian food products by: Capillary tube, viscometer, Hakke's viscometer, Rotational viscometer and Falling ball viscometer. Viscosity measurement using (RVA, Brookfield viscometer), Texture Profile Analysis of different food samples, Optical properties measurement using hunter Lab/CIE colour system, Optical properties measurement using Spectrophotometer, Optical properties measurement using Tintometer, To determine specific heat of some food grains, To find the thermal conductivity of different grains. To find the electrical impendence of the grain

Recommended Books / Manuals

1. Physical Properties of Plant and Animal Materials, 2nd Ed, Gordon & Breach Science Publisher *by* N.N. Mohsenin
2. Thermal properties of food and agricultural materials, Gordon & Breach Science Publisher *by* N.N. Mohsenin
3. Electromagnetic radiation properties of food and agricultural materials, Gordon & Breach Science Publisher *by* N.N. Mohsenin
4. Engineering Properties of Foods,3rd Ed, CRC Press *by* Rao, Rizvi & Dutta
5. Practical Manual on Post Harvest Technology, Published by Banaras Hindu University, Varanasi, *by* R. C. Pradhan and P. P. Said.

FP 273	Food Microbiology Laboratory	2 credits [0-0-3]

Objectives: To learn basics of microbiology in food processing

Syllabus:

Basic food microbiology laboratory procedures and culture techniques. Enumeration of microorganisms in foods by most probable technique. Microbiological examination of raw and pasteurized milk. Evaluation of microbial quality of milk by dye reduction test. Estimation of total bacterial count, coliform count and mold of fruit juices. Enumeration of pychrotrophic, thermoduric and thermophilic bacteria in food sample. Enumeration of anaerobic spore forming bacteria in canned foods. Isolation of pure culture. Isolation and enumeration of microorganisms in food. Procedures of quality assurance in food microbiology laboratory. Maintenance of food microbiology lab equipment and instrument. Microbiological standards of food and lab auditing.

Recommended Books:

1. Food Microbiology Laboratory *by* McLandsborough. CRC Press
2. Laboratory Methods in Food Microbiology *by* Harrigan. Gulf Professional Publishing
3. Practical Food Microbiology *by* Diane Roberts, Melody Greenwood, Wiley
4. Laboratory Manual of Food Microbiology *by* Garg, Garg, Mukerji.

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 273	Food Microbiology laboratory	✓	✓			✓				✓			

FP 210 **Food Chemistry** **4 credits [3-1-0]**

Objective: To learn fundamentals of food chemistry.

Syllabus:

Food chemistry and its role in food processing. Water: Importance of water in foods, Structure of water & ice, Concept of bound and free water and their implications. Proteins: Nomenclature, classification, structure, chemistry and properties of amino acids, peptides, proteins; Essential and non-essential amino acids, Qualitative and quantitative analysis of amino acids and proteins, Changes during food processing. Carbohydrates: Nomenclature and classification, structure, physical and chemical properties of polysaccharides and their functions; Qualitative and quantitative analysis of carbohydrates; changes in carbohydrates during food processing. Lipids: Structure, classification, physical and chemical properties, utilization of fats and oils, margarine, shortenings, salad and cooking oils, importance of fats and oils in diet, introduction to hydrogenation and its importance. Browning reactions: Enzymatic and non-enzymatic browning, advantages and disadvantages, factors affecting their reaction and control. Vitamins and minerals: Types of vitamins and minerals, chemistry and functions, sources and deficiency diseases. Plant pigment: Importance, structure and properties of plant pigments, chemical changes of in pigments during food processing. Flavour and aroma of foods: Importance, structure and properties of flavouring and aromatic components of foods.

Recommended Books:

1. Food Chemistry *by* Meyer
2. Food Chemistry *by* Fennema
3. Food Chemistry *by* Belitz
4. Basic Food Chemistry *by* Lee
5. Principles of Biochemistry *by* Lehnninger

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 210	Food Chemistry	✓	✓	✓	✓					✓			

FP 212	Processing of Food Grains and Horticultural Products	4 credits [3-1-0]

Objective: To learn various processes and methods of Food Grain and Horticultural Processing

Syllabus:

Production, Economics, and processing scenario of Food grains. Classification, structure and physico-chemical properties and thermal properties of Food grains; Unit operations and equipment for Food Grain Processing , Processing and storage of cereals, pulses and oil seeds. Commercial processing of Paddy, wheat, Corns, Barley, Millets, Pulses and Oil seeds.

Production and processing scenario of horticultural products; basics of ripening, maturity, harvesting, handling, packaging, transport, storage and Quality of fruits and vegetables. Principles, unit operations and Equipment for processing and preservation of fruits and vegetables. Processing technology for jam, jelly, marmalade, preserve, pickles, chutneys, ketchups, sauces, beverages, powder and canned products.

Recommended Books

1. Post harvest technology of Cereals, Pulses and Oil Seeds *by* A Chakravarti
2. Unit Operations in Agricultural Processing *by* Sahay and Singh
3. Preservation of Fruits and Vegetables, *by* Lal, Siddappa and Tandon
4. Fruit and Vegetable Preservation: Principles and Practices *by* Srivastava and Kumar

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 212	Processing of Food Grains and Horticultural Products	✓	✓	✓	✓					✓			

FP 224	Unit Operations in Food Processing	4 credits [3-1-0]

Objective: To learn various unit operations involved in food processing

Syllabus:

Cleaning, Sorting, Grading, Size reduction: Grinding, Cutting, Emulsification, homogenization, energy concept in size reduction, Kick's law, Rittinger's law, Bond's law. Grinding and milling equipment. Mechanical separations: Sedimentation and filtration, Sieving / Screening, Sieve analysis. Basics of various Unit Operations: Evaporation, Drying, Dehydration, Pasteurization, Sterilization, Blanching, Chilling, Freezing, Parboiling, Extrusion, Frying, Baking, Roasting, Puffing, Agitation and mixing, Irradiation and non-thermal processing operations. Utilities and Sanitation in Food Processing.

Recommended Books:

1. Post harvest technology of Cereals, Pulses and Oil Seeds *by* Chakravarti
2. Unit Operations of Chemical Engg *by* McCabe and Smith
3. Unit operations in Agril processing *by* Sahay and Singh
4. Unit Operations in Food Processing *by* Earle
5. Food Processing Technology: Principles and Practice *by* Fellows
6. Fundamentals of Food Process Engineering *by* Toledo

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 224	Unit Operations in Food Processing	✓	✓	✓	✓					✓			

FP 272 Food Chemistry Laboratory 2 credits [0-0-3]

Objective: To learn basic chemistry of Food

Syllabus:

Estimation of moisture content in a given food sample, Estimation of reducing sugars by Lane and Eynon method, Estimation of crude fibre content in food samples, Determination of protein by Kjeldahl's method, Estimation of total ash, acid soluble and water soluble ash, Extraction of fat from given food sample by Soxhlet apparatus, Determination of smoke point and percent fat absorption for different fats and oils, Determination of percent free fatty acids in given food sample, Estimation of peroxide value in fats and oils, Estimation of iodine value in oils, Estimation of saponification value in oils, Determination of refractive index of fats and oils, Determination of specific gravity of fats and oils, Estimation of antinutritional factors (Trypsin inhibitor) in foods, Determination of carotenoids with respect to flour pigments, Estimation of water activity in a given sample of food

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 272	Food Chemistry Laboratory	✓	✓		✓					✓			

FP 274 Food Grains Processing Laboratory 2 credits [0-0-3]

Objective: To learn various processes and methods of Food Grain and Horticultural Processing

Syllabus:

Physical properties of cereals, pulses and oil seeds, Milling Characteristics of Food Grains, Size reduction and sieve analysis. Study of temperature and time on parboiling of rice, Effect of parboiling on nutrient content of paddy. Determination of cooking quality of rice, Determination of gelatinization temperature of rice, Study on cooking quality of pulses. Determination of Oil Content. Methods for Oil expressions.

Course Outcomes	POs

		a	b	c	d	e	f	g	h	i	j	k	l
FP 274	Food Grains Processing Laboratory	✓	✓		✓					✓			

FP 331 Heat and Mass Transfer 4 credits [3-1-0]

Objective: To learn the basic concept of heat and mass transfer in food processing

Syllabus:

Introductory concepts, modes of heat transfer, thermal conductivity of materials, measurement. General differential equation of conduction. One dimensional steady state conduction through plane and composite walls, tubes and spheres with and without heat generation. Electrical analogy. Insulation materials, critical thickness of insulation. Fins, Free and forced convection. Newton's law of cooling, heat transfer coefficient in convection. Dimensional analysis of free and forced convection. Useful non dimensional numbers and empirical relationships for free and forced convection. Equation of laminar boundary layer on flat plate and in a tube. Laminar forced convection on a flat plate and in a tube. Combined free and forced convection. Introduction. Absorptivity, reflectivity and transmissivity of radiation. Black body and monochromatic radiation, Planck's law, Stefan-Boltzman law, Kirchoff's law, grey bodies and emissive power, solid angle, intensity of radiation. Radiation exchange between black surfaces, geometric configuration factor. Heat transfer analysis involving conduction, convection and radiation by networks. Types of heat exchangers, fouling factor, log mean temperature difference, heat exchanger performance, transfer units. Heat exchanger analysis restricted to parallel and counter flow heat exchangers. Steady state molecular diffusion in fluids at rest and in laminar flow, Flick's law, mass transfer coefficients. Reynold's analogy.

Recommended Books:

1. Biological and Bioenvironmental Heat and Mass Transfer by Datta
2. Heat And Mass Transfer By Nag
3. Heat And Mass Transfer , Second Edition by Sawhney

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 331	Heat and Mass Transfer	✓	✓	✓	✓	✓				✓			✓

FP 333 Dairy Process Engineering 4 credits [3-1-0]

Objective: To understand the principles of Dairy processing and milk products processing

Syllabus:

Milk reception and principals of milk processing: milk storage, bulk cooling, stirring and mixing, pasteurization, sterilization, centrifugation, homogenization, evaporation and condensation. Spray drying of milk, principle and equipment: spray dryer, cyclone separator. Manufacturing of milk products and principles of processing of cheese, ice-cream, butter, special milk products, casein, whey, curd, butter milk etc. Equipment for indigenous milk products manufacturing. Milk ultra-filtration and reverse osmosis. Filling Operations: Principles and working of different types of bottle filters and capping machine, pouch filling machine, pre-pack and aseptic filling. Filling and Packaging machines for milk and milk products, aseptic packaging. Bulk milk handling system, care and maintenance. Hygienic design concepts, sanitary pipes and fittings, CIP system. Preventive maintenance program for Dairy Plant. Maintenance organization, development of optimum organization planned overhaul and PERT planning, Utilities and sanitation in processing plant.

Recommended Books:

1. Engineering for dairy and food products by A W Farrall. John Wiley and Sons
2. Outlines of dairy technology by Sukumar De. Oxford University Press
3. Dairy Plant System and Layout by Tufail Ahmed, Kitab Mahal, Allahabad

Supplementary Readings:

1. Indian dairy products by K S Rangappa Asia Publishing House
2. Cheese and Butter by V. Cheke and A. Sheeprd, Agrobios (India)
3. Dairy chemistry and biochemistry by P F Fox and PLH McSweeney, Blackie Academic and Professional, An Imprint of Chapman & Hall, London.
4. Milk and Milk Products by Eckles and Eckles

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 333	Dairy Process Engineering	✓	✓	✓	✓	✓	✓			✓			

FP 335 Refrigeration and Air Conditioning Engineering 4credits [3-1-0]

Objective: To study the principles of heating, ventilating, air conditioning and refrigeration systems and enable students to achieve effective and efficient design solutions.

Syllabus:

Fundamentals of refrigeration and air conditioning. Refrigerating Machine: The second law interpretation, heat engine, heat pump and refrigerating machine. Carnot Cycle. Methods of Producing Low Temperatures. Types of Refrigeration Systems: Air cycle refrigeration systems, vapour compression refrigeration systems, vapour absorption refrigeration systems. Vapour Compression System: Components of vapour compression refrigeration system, coefficient of performance. Cycle Diagrams and Simple Saturated Cycles: Different types of refrigerants, desirable properties of refrigerants, safety and economical aspects. Air Conditioning: Mixing process, basic processes in conditioning of air, psychrometric processes in air conditioning. Air conditioning system, state and mass rate of supply air. Applications of Refrigeration in Food Processing and Preservation: cold store, automated cold stores, security of operations, cold storage for fruits and vegetables. Principles of refrigeration of boned, boxed and processed meats, pork and bacon, poultry, fish and seafood. Refrigeration of milk and milk products, ice-cream, ice lollies, brewing, wines and spirits, soft drinks. Cooling of bakery products, cook/chill process, chocolate enrobing. Refrigerated transport, handling and distribution, cold chain, refrigerated product handling, order picking, refrigerated vans and refrigerated display. Refrigeration load estimation.

Recommended Books:
1. Principles of Refrigeration by Dossat R.J. Published by John Wiley
3. Advances in food refrigeration by Da Wen Sun. Published by Woodhead Publishing Limited, UK

Supplementary Reading:
1. Refrigeration and Air-conditioning by CP Arora. Published by Tata McGraw Hill
2. Refrigeration and Air-conditioning by Manohar Prasad. Published by New Age publications.
3. Commercial Cooling of Fruits and Vegetables by Thompson. Published by Univ. of California

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 335	Refrigeration and Air Conditioning Engineering	✓		✓	✓	✓	✓	✓		✓			

FP 337 Food Packaging and Storage Engineering 4 credits [3-1-0]

Objective: Understanding of food packaging development, packaging systems and analyze complex systems of food packaging and logistics with simulation models.

Syllabus:

Function of packaging, marketing consideration for a package and types of packaging. Barrier properties of packaging material, gas permeation rates- oxygen transmission rate (OTR), water vapour transmission rate (WVTR), bursting strength, tensile strength, tearing strength, drop test, puncture test, etc. Packaging materials for foods. Selection criteria of packaging materials for raw and processed food products. Machinery for Packaging: Form fill and seal machines, vacuum packaging machine, shrink wrap packaging machine and multilayer packaging system. Package labelling: functions, nutrition labelling, ingredient characterization handling instruction, and regulations; Shelf life of packaged food: water activity and prediction of shelf life. Packaging logistics. Food Storage: Importance of scientific storage systems, post-harvest physiology of semi-perishables and perishables, climacteric and non-climacteric fruits, respiration, ripening, changes during ripening, ethylene biosynthesis. Product damages during storage. Storage structures: Traditional, improved and modern storage structures; farm silos. Stored grain management and aeration: moisture and temperature changes in stored grains; conditioning of environment inside storage, purposes of aeration, aeration theory and aeration system operation. Storage pests and control: Damage due to storage insects, pests, rodents and its control. Storage of perishables: cold storage, controlled and modified atmospheric storage, hypoboric storage, evaporative cooling storage, conditions for storage of perishable products, control of temperature and relative humidity inside perishable storage

Recommended Books:
1. Food Packaging: Principles and Practice, Second Edition, by Gordon L. Robertson, CRC Press

2. Handbook of Postharvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices, *by* A. Chakraverty, A. S. Mujumdar, G.S.V. Raghavan, H.S. Ramaswamy. Marcel Dekker, Inc., NY Grain Storage Engineering and Technology, Batra Book Services *by* Vijayaraghavan, S.
3. Food Packaging and Preservation by M. Mathlouthi. Blackie Academic & Professional

Supplementary Readings:

1. Hermeticity of Electronic Packages by Hal Greenhouse, William Andrew Publishing, LLC, Norwich, New York, U.S.A.
2. Storage of Cereal Grains and Their Products, 4th Edition, AACC by David B. Saucer.
3. Principles of Agricultural Engineering, Volume – II, Jain Brothers by A. M. Michael and T. P. Ojha.
4. Handling and Storage of Food Grains in Tropical and Subtropical Area by FAO Pub.
5. Silos, Theory and Practice: Vertical Silos, Horizontal Silos (retaining Walls), 2nd Ed, Lavoisier Pub. by André M. Reimbert
6. Fruit and Vegetables: Harvesting, Handling and Storage, 2nd Ed, Iowa State Press by Keith Thompson

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 337	Food Packaging and Storage Engineering	✓	✓		✓				✓				

FP 371 Heat and Mass Transfer Laboratory 2 credits [0-0-3]

Objective: To learn the basic concept of heat and mass transfer in food processing

Syllabus:

Introductory concepts, modes of heat transfer, thermal conductivity of materials, measurement. General differential equation of conduction. One dimensional steady state conduction through plane and composite walls, tubes and spheres with and without heat generation. Electrical analogy. Insulation materials, critical thickness of insulation. Fins, Free and forced convection. Newton's law of cooling, heat transfer coefficient in convection. Dimensional analysis of free and forced convection. Useful non dimensional numbers and empirical relationships for free and forced convection. Equation of laminar boundary layer on flat plate and in a tube. Laminar forced convection on a flat plate and in a tube. Combined free and forced convection. Introduction. Absorptivity, reflectivity and transmissivity of radiation. Black body and monochromatic radiation, Planck's law, Stefan-Boltzman law, Kirchoff's law, grey bodies and emissive power, solid angle, intensity of radiation. Radiation exchange between black surfaces, geometric configuration factor. Heat transfer analysis involving conduction, convection and radiation by networks. Types of heat exchangers, fouling factor, log mean temperature difference, heat exchanger performance, transfer units. Heat exchanger analysis restricted to parallel and counter flow heat exchangers. Steady state molecular diffusion in fluids at rest and in laminar flow, Flick's law, mass transfer coefficients. Reynold's analogy.

Recommended Books:

1. Biological and Bioenvironmental Heat and Mass Transfer by Datta
2. Heat And Mass Transfer By Nag
3. Heat And Mass Transfer , Second Edition by Sawhney

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 371	Heat and Mass Transfer	✓	✓	✓	✓	✓	✓			✓			

FP 373 **Unit Operations in Food Processing Laboratory** **2 credits [0-0-3]**

Objective: To learn various unit operations involved in food processing

Syllabus:

Cleaning, Sorting, Grading, Size reduction: Grinding, Cutting, Emulsification, homogenization, energy concept in size reduction, Kick's law, Rittinger's law, Bond's law. Grinding and milling equipment. Mechanical separations: Sedimentation and filtration, Sieving / Screening, Sieve analysis. Basics of various Unit Operations: Evaporation, Drying, Dehydration, Pasteurization, Sterilization, Blanching, Chilling, Freezing, Parboiling, Extrusion, Frying, Baking, Roasting, Puffing, Agitation and mixing, Irradiation and non-thermal processing operations.

Recommended Books:

1. Post harvest technology of Cereals, Pulses and Oil Seeds *by* Chakravarti
2. Unit Operations of Chemical Engg *by* McCabe and Smith
3. Unit operations in Agril processing *by* Sahay and Singh
4. Unit Operations in Food Processing *by* Earle
5. Food Processing Technology: Principles and Practice *by* Fellows
6. Fundamentals of Food Process Engineering *by* Toledo

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 224	Unit Operations in Food Processing Lab	✓	✓	✓	✓					✓			

FP 375 **Horticultural Processing Laboratory** **2 credits [0-0-3]**

Objective: To learn various processes and methods of Food Grain and Horticultural Processing

Syllabus:

Preparation of fruit jam from Fruits, Preparation of fruit jelly from Fruits, Preparation of Jelly, Squash, Qualitative determination of pectin content by alcohol test / jelmeter test in fruit extract, Preparation of ready to serve (RTS) from mango/ litchi/ lemon, Preparation of fruit leather -mango leather , Preparation and preservation of tomato puree and ketchup

Course Outcomes	POs

		a	b	c	d	e	f	g	h	i	j	k	l
FP 375	Horticultural Processing Laboratory	✓	✓	✓	✓	✓				✓			

FP 377 Dairy Process Engineering Laboratory 2 credits (0-0-3)

Objectives: To understand the hygienic characteristics of dairy plant and various dairy processes.

Syllabus:

Identification of hygienic characteristics of pipes and fittings in dairy plant; To study CIP system for dairy plant; description of technical specifications of milking and storage equipment; description of technical specifications of equipment for chilling & pasteurization; description of features of centrifuges and operation; working principle of ice-cream freezers & packing machine; design and principle of working of cheese vat; working principle of milking machine; working principle of press & packing machine; description of butter manufacturing equipment; description of different types of evaporators used in dairy industry; description of different types of dryers used in dairy industry; description of operation of spray dryers used in dairy industry; operation of drum an vacuum dryers used in dairy industry; design of milk collecting and chilling unit; Visit to dairy industry

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 377	Dairy Process Engineering Laboratory	✓	✓	✓	✓			✓	✓				

FP 372 Food Process Equipment and Plant Design Laboratory 2 credits [0-0-3]

Objective: To acquire basic understanding of design parameters, design procedures for food process equipment and their attachments in food processing plant.

Syllabus:

Study of materials for fabrication, mechanical properties, ductility, hardness, corrosion, protective coatings, corrosion prevention linings equipment, choice of materials, material codes. Design Considerations: Stresses created due to static and dynamic loads, combined stresses, design stresses and theories of failure, safety factor, temperature effects, radiation effects, effects of fabrication method, economic considerations. Design of Pressure and Storage Vessels. Design of Heat Exchangers. Design of Evaporators and Crystallizers. Design of Agitators Separators for liquid foods. Design of Equipment Components. Design of Freezing Equipment, Dryer, Conveyors, Elevators, Extruders. Study of hazards and safety considerations in designing process equipment. Food processing plant design: Feasibility Study, Plant Location, Plant Size, Procedures for estimation of economic plant size (breakeven analysis and optimization), estimation of volume of production for each product. Utilities and Sanitation in Processing Plant. Product and Process Design. Plant Layout design, Planning and Design of Service Facilities and Plant Surroundings, Design and installation of piping system. Selection of Equipment. Workers Safety and Health Aspects. Building and Building Materials selection for food plants.

Recommended Books:

1. Process equipment design by Joshi MV and Mahajan VV. Published by Macmillan India Ltd
2. Process equipment design by Brownell and Young. Published by John Willey
3. Chemical Engineering Plant Design by Villbrandt F.C. and Dryden C.E. McGraw-Hill
4. Plant Layout and Design by J.M. Moore. The Mcmillan company

Supplementary Reading:

1. Process equipment design by Bhattacharya BC. Macmillan India Ltd
2. Strength and elasticity of materials by Brooks WH. Asia Publishing House
3. Process Plant Design by Backhusrt J.R. and J.H. Barker. Heimann Educational Books, London
4. Computer Aided Process Plant Design by Leesley M.E. Gulf Publishing Company, Houston
5. Project Management for Engineers by M.D. Rosenau. Van Nostrand Reinhold Co., New York

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 372	Food Process Equipment and Plant Design Laboratory	✓	✓	✓	✓	✓				✓			

FP 374 Refrigeration and Air Conditioning Engineering Laboratory 2 credits [0-0-3]

Objectives: To understand refrigeration cycle principles as it applies to installing, working and trouble-shooting of equipment.

Syllabus:

Study of vapour compression refrigeration system and determination of COP of vapour compression refrigeration system. Study of various types of compressors, condensers, expansion valves and evaporative coils used in refrigeration systems. Study of refrigerants, their properties and charts. Study of direct and indirect contact freezing equipment for foods. Spray freezing of foods. Estimation of refrigeration load for cold storage. Estimation of refrigeration load for meat and poultry products. To calculate refrigeration load of a dairy plant. Estimation of refrigeration load for ice-cream manufacturing. To study cooling system for bakery and estimation of refrigeration loads. To estimate refrigeration load during chocolate enrobing process. Study of refrigerated van and calculation of cooling load during transport in different weather conditions. Deep freezing and thawing of fish. To study refrigerated display of foods and estimation of cooling load.

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 374	Refrigeration and Air Conditioning Engineering Laboratory	✓	✓	✓	✓	✓	✓	✓	✓	✓			

FP 376 — Food Packaging and Storage Design Laboratory — 2 credits (0-0-3)

Objectives: To gain knowledge about different kind of packaging and storage of Food.

Syllabus:

Classification of various packages based on material and rigidity; Measurement of thickness of paper, film, paper boards; Determination of wax weight in paper packaging; Measurement of grammage and water absorption of paper of paper boards; Measurement of bursting strength of paper of paper boards; Measurement of tear resistance of packaging material; Measurement of puncture resistance of packaging material; Measurement of tensile strength of packaging material; Measurement of grease resistance of papers; Determination of gas transmission rate of package films; Determination of coating on package materials; Identification of plastic films; Study of packaging film for their labelling characteristics and specifications; Pre-packaging practices followed for packing fruits, vegetables; Demonstration of can-seaming operation; Determination of shelf life of food product

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 376	Food Packaging and Storage Design Laboratory	✓	✓	✓	✓			✓	✓				

FP 378 — Food Analysis and Quality Control Laboratory — 2 credits (0-0-3)

Objectives: To gain knowledge of various methods for food quality analysis and control.

Syllabus:

Training of sensory panel for flavor perception; sensitivity tests for four basic tastes; difference tests, triangle test, paired comparison test, duo trio test; Sensory evaluation of milk and detection of flavour defects in milk; Sensory evaluation of food samples for textural properties; detection of common adulterants- formaldehyde, starch, cane sugar, hydrogen peroxide, sodium bicarbonate in milk; Test for the presence of sesame oil in given oil sample; Colour estimation of food samples by tintometer; Examination of fruit jams for FPO specifications; Examination of Butter / oil samples for AGMARK specifications; Examination of food / milk products for BIS specifications; determination of BAR (Brix acid ratio) in beverages; Visit to units with ISO 22000:2005 certified company; Evaluation of food labels of products for PFA standards; Determination of total residual chlorine in water sample; Cut out analysis of Canned Product samples.

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 378	Food Analysis and Quality Control Laboratory	✓	✓	✓	✓			✓	✓				

FP 471 Livestock, Fish and Marine Products Processing Laboratory 2 credits [1-0-2]

Objectives: To understand the principles of food product development and processing of products originating from animal, fish and marine sources.

Syllabus:
Pre-slaughter operations of meat and poultry. Visit to abbatoir. Meat cutting and handling. Evaluation of animal carcasses. Evaluation of meat and study of post rigor changes. Preparation of smoked meat and preservation of meat. Preparation and evaluation of dehydrated meat products. To study the effect of preservatives/antibiotics on shelf life of meat. Preparation and evaluation of pickled meat. Preparation and evaluation of meat sausages. Preparation and evaluation of meat/ chicken patties. Evaluation of quality and grading of eggs. Evaluation of quality of fish (in terms of freshness). Preparation of egg/fish pickle. Chilling operation of fish. Processing and product development from important marine products. Visit to meat processing industry. Experiments on by-products utilization of meat.

Essential Readings:
1. Meat Science by R.A. Lawrie, 2nd Edition, Pergamon Press, Oxford UK.
2. Egg Science and Technology by W.J. Stadelmen, and O. J. Cotterill, 1977. 2nd Edition. AVI, Westport.
3. Muscle as Food by PJ Bechtel, Orlando, FL, Academic Press.
4. Marine and Freshwater Products Handbook by R.E. Martin, E.P. Carter, G.J. Flick and L.M. Davis, Technomic Publications

Supplementary Readings:
1. Meat Handbook by A. Lavie, 4th Edition, AVI, Westport.
2. HACCP in Meat, Poultry and Fish processing

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 471	Livestock, Fish and Marine Products Processing Laboratory	✓	✓	✓	✓			✓	✓				

FP 473	Food Process Modeling and Simulation Laboratory	2 credits (1-0-2)

Objectives: To understand and formulation experiments, analyse the dependent and independent variables and their effect on response, construct predictive models and Perform various statistical analyses.

Syllabus:

Introduction to basic mathematical modelling, empirical models, ODE and PDE and their solve, Identification of design, Factorial, fractional factorial and rotatable central composite experimental design. Developing empirical equations using experimental data. operating and performance parameters in mechanical, thermal and mass transfer operations carried out in food processing such as; particulate size reduction, homogenization, centrifugation, packaging, mixing, conveying, extrusion, storage, heating, cooling, freezing, puffing, frying, distillation, extraction, concentration and drying. Developing mathematical relationship between the independent and dependent variables affecting the food processing operations by using physical and chemical principles governing the processes. Developing predictive model using Neural network. Optimization of processing parameters using Genetic algorithms. Application of Fuzzy logic to sensory evaluation and ranking of foods. Finite difference and finite element method, Principle component analysis.

Recommended Books

1. Food Processing Operations Analysis by H. Das. Asian Books Private Limited
2. Handbook of Food Process Modeling and Statistical Quality Control by Mustafa Ozilgen, CRC Press

Suggested Readings

1. Food Processing Operations Modeling: Design and Analysis, Second Edition (Google eBook) Soojin Jun, Joseph M. Irudayaraj, CRC Press
2. Handbook of Food and Bioprocess Modeling Techniques Editor(s): Shyam S. Sablani, Ashim K. Datta, M. Shafiur Rahman, Arun S. Mujumdar, CRC Press

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 473	Food Process Modeling and Simulation Laboratory	✓	✓	✓	✓			✓	✓				

FP 472	Experimental Design and Statistical Methods Laboratory	2 credits (1-0-2)

Objectives: To learn about various methods experimental design and statistical methods

Syllabus:

Descriptive statistics, Mean, Variance, Probability, Probability distribution. Data and its nature, data representation, diagrams and graphs using MS Excel, Measure of central tendency, Dispersion, Swekness and Kurtosis. Basic statistical concepts, concepts Strategy of experiments, basic principles, guidelines for designing experiments and importance of designed experiments in research. Full factorial design, 2K design, completely randomized design, randomized block design, central composite design, factorial design, Box Behenken design, Analysis of variance. Introduction to theory of estimation and confidence-intervals, Correlation and Regression, Simple and multiple linear regression model, Partial correlation coefficient, test of significant of correlation coefficient and regression coefficient, Coefficient of determination, Testing of heterogeneity. Multivariate relationships, multiple linear regression, multiple and partial correlation, significance of testing in multiple correlation, variable selection in multiple regression. Multiple regression analysis, variable selection.

Recommended Books

1 Statistical Methods *by* W. G. Cocharan
2 Statistical Methods S Chand & Sons, *by* S P Gupta
3 Computer aided techniques in Food Technology *by* Israel Saguy
4 Basic Statistics, New Age Publishers, *by* B L Aggarwal

Reference books

1 Response surface methodology *by* R. H. Myers
2 Response surfaces design and analysis *by* A. I. Khuri & J. A. Cornell

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 472	Experimental Design and Statistical Methods Laboratory	✓	✓	✓	✓			✓	✓				

B. PROFESSIONAL ELECTIVE COURSES

FP 312	Processing of Spices, Condiments and Plantation crops	3 credits (3-0-0)

Objectives: To gain knowledge about processing of Spices, Condiments and Plantation crops

Syllabus:

Classification, composition, structure and characteristics. production status of spices in India: major spice producing area in India and world wide, export potential of processed and raw spice product. Processing of major and minor spices: Preservation and processing of major and minor spices of India; Processing of whole spice, spice powder, paste and extracts; production and processing of spice mixtures; spice oils and oleoresins, functional role of spices, quality specification for spices. Tea Processing: Composition and production of tea leaves; processing of tea leaves; CTC tea, black tea, green tea and Oolong tea, grading and packaging; processing of instant tea. Coffee Processing: Production and processing of coffee cherries by wet and dry method; processing technology for coffee; preparation of brew; processing technology for instant coffee and decaffeinated coffee. Cocoa processing: Cocoa bean- introduction, history and composition; processing of cocoa bean; processed products of cocoa.

Recommended Books

1. Major spices of India-Crop Management – Post Harvest Technology by J S Pruthi, Indian Council of Agricultural Research, New Delhi.
2. Coffee processing technology By M Sivetz and H. E. Foote, AVI Publishing, Co.
3. Chemistry and Applications of Green Tea by T Yamamoto, L R Juneja, D-chi Chu ad M. Kim, CRC Press

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 312	Processing of Spices, Condiments and Plantation crops	✓	✓		✓				✓				

FP 332	Food Process Equipment and Plant Design	3 credits (3-0-0)

Objectives: To conceptualize and design equipment needed for various food processing operations.

Syllabus:

Materials and Properties, Design Considerations, Design of Pressure and Storage Vessels, Design of shell and its component, Design of Heat Exchangers, Design of Evaporators and Crystallizers, Design of crystalliser and entrainment separator. Design of Agitators Separators, Design of centrifuge separator. Design of Equipment Components: Design of Freezing Equipment: Design of tray dryer, tunnel dryer, fluidized dryer, spray dryer, vacuum dryer, freeze dryer and microwave dryer. Design of Conveyors and Elevators, Design of Extruders, Design of Fermenters, Hazards and Safety Considerations. food plant design concepts, Feasibility Study: Design of product, product specifications, process design, process selection considering technical, economic and social aspects. Process planning and scheduling, flow sheeting, flow diagrams and process flow charts and computer aided development of flow charts; Selection of Process equipments, material handling equipment, service equipment, instruments and controls, considerations involved in equipment selection, economic analysis of equipment. Types of layouts, preparation and development of layout, equipment symbols, flow sheet symbols, electric symbols, graphic symbols for piping systems, standards for space requirement and dimensions. Requirements of the steam, refrigeration, water, electricity, waste disposal, lighting, ventilation, drainage, CIP system, dust removal, fire protection etc. Workers Safety and Health Aspects, Building and Building Materials.

Text books

1. Process equipment design by Joshi MV and Mahajan VV. Published by Macmillan India Ltd
2. Process equipment design by Brownell and Young. Published by John Willey
3. Food Plant Economics by Z.B. Maroulis and G.D. Sarvacos. Published by CRC press
4. Chemical Engineering Plant Design by Villbrandt F.C. and Dryden C.E. Published by McGraw-Hill
5. Plant Layout and Design by J.M. Moore Published by The Mcmillan company
6. Chemical Engineering Handbook by Perry R.H. Published by McGraw-Hill

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 332	Food Process Equipment and Plant Design	✓	✓	✓	✓				✓				✓

FP 334 Biochemistry and Human Nutrition 3 credits (3-0-0)

Objectives: To learn biochemistry and nutritional aspect of foods

Syllabus:

Nutrition, malnutrition, functions of food, basic food groups, nutritional needs, requirements and recommended allowances of foods; Mechanism of enzyme action, coenzymes, enzyme kinetics, Derivation of Michaelis-Menten Equation. Sources, functions, digestion, absorption, assimilation and transport of carbohydrates, proteins and fats in human beings. Metabolism of carbohydrates: Respiration (TCA cycle), Metabolism of lipids, Metabolism of proteins. Functions, sources, factors affecting absorption of minerals, absorption promoters and inhibitors, effect of deficiency of Calcium, phosphorus, iron, zinc, iodine, fluorine and copper. Vitamins and hormones: Classification, functions, sources, effects of deficiency. Changes during food processing operations, restoration, enrichment, fortification and supplementation of foods.

Recommended books

1 Principles of Biochemistry *by* A L Lehninger
2 Text book of Biochemistry *by* E S West, W R Todd, H S Mason and J T Van Bruggen
3 Nutrition and Dietetics, Tata McGraw-ill Co. Ltd *by* Shubhangini A Joshi

Reference books

1. General Biochemistry *by* J H Weil
2. Biochemistry of Foods, Academic Press *by* A M Eskin
3. Food Chemistry, Marcel Dekkar Inc *by* O R Fennema
4. Essentials of Nutrition, Ganesh and Co *by* M Swaminathan
5. Outlines of biochemistry *by* Eric E Conn and P K Stumpf

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 334	Biochemistry and Human Nutrition	✓	✓	✓	✓				✓				✓

FP 352 Emerging Technology in Food Processing 3 credits (3-0-0)

Objectives: To learn about various emerging technologies in Food Processing Sector

Syllabus:
Introduction, scope and applications of High pressure processing of foods, Pulse electric fields processing (PEF), Osmotic dehydration, High intensity pulsed light Technology, Food Processing by Radio frequency Electric fields and electromagnetic radiations, Ultrasound in food processing, Food Irradiation. Recent Development in Microwave heating; Radio-Frequency processing; Ohmic heating; Combine Microwave Vacuum drying; New Hybrid Drying technologies; Vacuum cooling of foods; Concept of Minimal processing of Fruits and Vegetables products; Modified and Controlled Atmospheric Packaging for Minimally processed foods. Any other latest technologies for food processing.

Recommended Books

1. Thermal Food Processing – New technologies and Quality Issues *by* Da-Wen Sun
2. Advances in Thermal and Non-Thermal Food Preservation *by* Tewari and Juneja
3. Innovation in Food Engineering – New Techniques and Products *by* Passos and Ribeiro

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 352	Emerging technologies in Food Processing	✓	✓	✓	✓				✓				✓

FP 336 Functional Foods and Nutraceuticals 3 credits (3-0-0)

Objectives: To understand concepts of functional and nutraceutical food and their role in different disease control

Syllabus: Functional foods- concept and definition; nutraceutical-concept and definition. Probiotics and prebiotics food. Functional foods for treatment of gastrointestinal disorders. Functional Food and Nutraceuticals for the treatment of Coronary Heart Disease, Role of Functional Food and Nutraceuticals in Tumor, Functional Fats and Spreads, modified fats and oils. Functional Confectionery. Dietary Fibre Functional Products. Functional Food Health Claims: Functional claims; packaging and labeling; nutrient modification and specific nutrient claims; disease-specific claims; Dietary Supplement Health and Education Act (DSHEA). Market for Functional Food Products: Functional foods and consumers; the role of health in food choice; functional foods market; Regulations and laws for functional food.

Text books

1. Functional foods: Principles and technology by M Guo, Woodhead Publishing Limited, Abington Hall, Abington, Cambridge
2. Functional Foods Concept to Product by Glenn R. Gibson and Christine M. Williams, Woodhead Publishing Limited and CRC Press LLC

Reference books

1. Functional Dairy Products by T Mattila-Sandholm and M. Saarela, Woodhead Publishing Limited and CRC Press LLC

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 336	Functional Foods and Nutraceuticals	✓	✓	✓	✓				✓				✓

FP 338 Processing of Livestock, Fish and Marine Products 3 credits [3-0-0]

Objective: To learn various processes and methods for Processing of Livestock, Fish and Marine Product

Syllabus:

Production, Economics, and processing scenario of meat, fish and poultry. Preservation of meat- dehydration, freezing, pickling, curing, cooking and smoking; dehydration; curing; preservation of meat using ionizing radiation; preservation of meats using- antibiotics and chemical preservatives. Eating quality of meat and discoloration; water-holding capacity and juiciness in cooked and uncooked meat; texture and tenderness- definition and measurement, factors affecting texture and tenderness, artificial tenderizing. Abattoir design and layout, meat plant sanitation and safety, by-products utilization. Processing and preservation of eggs, production of egg yolk and egg yellow powder. Poultry processing: Unit operations for various poultry products; Fish processing: Unit operations for various fish products;

Recommended Books:

1. Meat Science *by* Lawrie
2. Meat Handbook *by* Lavie.
3. Egg Science and Technology *by* Stadelmen and Cotterill
4. Muscle as Food *by* Bechtel

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 338	Processing of Livestock, Fish and Marine Products	✓	✓	✓	✓					✓			

FP 323	**Beverage Technology**	**3 credits (3-0-0)**

Objectives: To describe the characteristics and production methods of both alcoholic and non- alcoholic beverage types.

Syllabus:
Types of beverages and their importance; status of beverage industry in India; Manufacturing technology for juice-based beverages; synthetic beverages; technology of still, carbonated, low-calorie and dry beverages; isotonic and sports drinks; role of various ingredients of soft drinks, carbonation of soft drinks. Specialty beverages based on tea, coffee, cocoa, spices, plant extracts, herbs, nuts, dairy and imitation dairy-based beverages. Alcoholic beverages- types, manufacture and quality evaluation; the role of yeast in beer and other alcoholic beverages, ale type beer, lager type beer, technology of brewing process, equipment used for brewing and distillation, wine and related beverages, distilled spirits. Packaged drinking water- definition, types, manufacturing processes, quality evaluation and raw and processed water, methods of water treatment, BIS quality standards of bottled water; mineral water, natural spring water, flavoured water, carbonated water.

Recommended Books

1. Handbook of Brewing by Hardwick WA.
2. Handbook of Food and Beverage Fermentation Technology by Hui.
3. Handbook of Brewing by Priest and Stewart.
4. Commercial Wine Making - Processing and Controls by Vine.
5. Beverages: Technology, Chemistry and Microbiology by Varnam and Sutherland
6. Beverages: Carbonated and Non-Carbonated by Woodroof and Phillips.

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 323	Beverage Technology	✓	✓	✓	✓				✓				✓

FP 325	**Food Analysis and Quality Control**	**3 credits (3-0-0)**

Objectives: To provide a basic understanding of Food analysis and concepts of quality control in food processing.

Syllabus:
Quality Control and its importance, Methods of colour determination and their applications. Food flavours, factors affecting food product flavours, measurement of food flavours, theory of taste and smell. Food Rheology and viscosity: Shear stress, shear rate, torque, Newtonian and Non-Newtonian flow and their further classification, Factors affecting consistency and viscosity, measurement of viscosity and

consistency. Food texture, Physical characteristics of food, working of texture measuring instruments, Fruit pressure tester, puncture tester, succulometer, tenderometer, texturometer, maturometer, fibrometer, Texture Profile Analysis (TPA). Non Destructive Methods for food analysis, Near Infrared Spectroscopy (NIR), Nuclear Magnetic Resonance (NMR) and its application, Ultrasonic equipments, conductivity and resistivity meters. Principle and working of Gas chromatography (GC), High pressure liquid chromatography (HPLC), types of detectors used in GC and HPLC, Thin layer chromatography (TLC), Column Chromatography, chromatographic methods applied as quality control. Sensory evaluation: Objectives, panel selection, Different test methods and their groups such as difference tests, rating tests, sensitivity tests, Sensory scores, Food Safety and Regulations: Food Safety and Standards Act, Codex Alimentarius, ISO series, Good Manufacturing Practices (GMP), Good Hygienic Practices (GHP), Good Agricultural Practices (GAP), Genetically Modified Foods (GMF).

Recommended books

1 Pearson's Composition and Analysis of foods, by S Ronald, Addison & Wesley Publisher
Quality Control for Food Industry. Vol I and II AVI Publications *by* A Krammer
2 Food Quality Control *by* Manoranjan Kalia
3 Handbook of Analysis and Quality Control of fruits & Vegetables Products Tata Mc Grow Hill Publications. *by* S Ranganna

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 325	Food Analysis and Quality Control	✓	✓	✓	✓				✓				✓

FP 326 Food Product Development 3 credits (3-0-0)

Objective: To learn various methods and techniques for food product development

Syllabus:

Need, importance and objectives of formulation for new product development. Ideas, business philosophy and strategy of new product. Formulation based on sources availability and cost competitiveness for concept developments of new products. Standardization of various formulation and product design. Adaptable technology and sustainable technology for standardized formulation for process development. Process control parameters and scale-up, production trials for new product development at lab and pilot scale. Quality assessment of new developed products. Market testing and marketing plan. Costing and economic evaluation. Commercialization / product launch.

Recommended Books and Reading:

1. Food Product Development: Maximizing Success *by* Earle and Anderson
2. New Food Product Development: From Concept to Marketplace *by* Fuller
3. Food Product Development: From Concept to the Marketplace *by* Graf and Saguy

Course Outcomes	POs											
	a	b	c	d	e	f	g	h	i	j	k	l

FP 326	Food Product Development	✓	✓	✓	✓				✓				✓

FP 328 Food Industry by-product and waste Management 3 credits (3-0-0)

Objective: To learn various methods and techniques for Food Industry by-product and waste Management

Syllabus:

Various byproducts from Food Processing Industry: By products of cereals, legumes, oil seeds, dairy, fruit and vegetables processing industries and their uses. By products of meat and fish processing units and their uses. Uses of byproducts of agro based industries in various sector. Various laws and regulations for waste management in food processing industries, Food industry wastes, Waste treatment methods for Cereals, Fruits, vegetables, Meat, Fish, Dairy processing and Brewery Industries. Waste water treatment, zero-discharge and zero-emission system.

Recommended Books:

1. Utilization of By-Products and Treatment of Waste in the Food Industry *by* Oreopoulou and Russ
2. Handbook of Waste Management and Co-Product Recovery in Food Processing *by* Waldron
3. Waste Management for the Food Industries *by* Arvanitoyannis

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 328	Food Industry by-product and waste Management	✓	✓	✓	✓				✓				✓

FP 412 Food Laws, Regulations & Certifications 3 credits (3-0-0)

Objective: To learn various Laws, Regulations & Certifications for Food Processing

Syllabus:

Food Adulteration, Food Safety Management System. Mandatory and voluntary food laws. Various laws, regulations and Certifications for food processing. Essential Commodity Act, Prevention of Food Adulteration Act (PFA), Fruit Products Order (FPO), Meat Food Products Order (MFPO), Vegetable Oil Control Order, Agricultural Marketing and Grading Standards (AGMARK), Bureau of Indian Standards(BIS) and their certifications, Food Safety and Standards Authority of India (FSSAI), Food Safety and Standards Act and Regulations of India. Food Codex laws, Food and Drug Administration (FDA), International Organization for Standardization (ISO), Good Manufacturing Practices (GMP), Good Agricultural Practices (GAP), Hazard Analysis and Critical Control Point (HACCP).

Recommended Books and Reading

1. Food Regulation: Law, Science, Policy, and Practice *by* Fortin

2. Food Safety and Standards Act and Regulations *by* FSSAI

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 412	Food Laws, Regulations & Certifications	✓	✓	✓	✓				✓				✓

FP 414 Food Ingredients and Additives 3 credits (3-0-0)

Objectives: To understand the fundamentals of food ingredients and food additives and their role.

Syllabus:

Food ingredients and additives- definitions, classification and functions, need for food ingredients and additives, food preservatives, classifications, antimicrobial agents (types, mode of action and their application); Nutrient supplements & thickeners, polysaccharides, bulking agents, antifoaming agents, synergists, antagonists. Antioxidants (synthetic and natural, mechanism of oxidation inhibition), chelating agents: types, uses and mode of action Coloring agents: color retention agents, applications and levels of use, natural colorants, sources of natural color (plant, microbial, animal and insects), misbranded colors, color extraction techniques, color stabilization.Flavoring agents: flavors (natural and synthetic flavors), flavor enhancers, flavor stabilization, flavor encapsulation; Flour improvers: leavening agents, humectants and sequesterants, hydrocolloids, acidulants, pH control agents buffering salts, anticaking agents, etc. Sweeteners: natural and artificial sweeteners, nutritive and non-nutritive sweeteners, properties and uses of various sweeteners in food products; Emulsifiers: Types, selection of emulsifiers, emulsion stability, functions and mechanism of action. Additives, food uses and functions in formulations; permitted dosages.

Recommended Books

1 Natural food additives, ingredients and flavourings *by* D. Baines.
2 Fenaroli's Handbook of Flavor Ingredients *by* Gerorge
3 Food Antioxidants: Technological,Toxicological and Health Perspective *by* Madhavi, Deshpande and Salunkhe
4 Food Flavours, Part A, B & C *by* Morton and Macleod

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 414	Food ingredients and food additives	✓	✓	✓	✓				✓				✓

FP 421 Bakery and Confectionary Technology 3 credits (3-0-0)

Objectives: To learn various aspects of Bakery and Confectionary technology.

Syllabus:

Historical development and status of bakery industry in India; introduction and definition of bakery products-bread, biscuit, cake, pastries, rusk, crackers. PFA specifications of bakery products. Bread-types; role of major and minor ingredients; processes of bread making; problems associated with bread; equipment for bread manufacturing; processing steps for biscuit, cookies, cracker, cakes and their major and minor ingredients. Nutritional aspect of bakery products; quality evaluation of baked products. Confectionary- historical development; classification of confectionary products; basic technical considerations for confectionary products- TS, TSS, pH, acidity, ERH, RH etc. raw materials and their role in confectionary product; traditional confectionary products. Cocoa bean- introduction, history and composition; processing of cocoa bean; processed product of cocoa; historical development in chocolate processing; ingredients and their role in chocolate; processing steps of chocolate processing- mixing, refining, conching, tempering, molding, cooling, coating, enrobing etc. High boiled sweets/candy - composition, production and preparation of high boiled sweets- traditional, batch and continuous method; toffee-composition, types, ingredient and their role, batch and continuous method of toffee manufacturing;

Recommended Books

1. Biscuit, cracker and cookie recipes for the food industry, Woodhead Publishing Ltd and CRC Press LLC by Duncan Manley
2. Baking problems solved Woodhead Publishing Ltd and CRC Press LLC *by* S Cauvain and L Young
3. Bakery Science & Technology, 3rd Ed. Vol-I, II, Sosland Publishers *by* E. J. Pyler
4. Flat Bread Technology, Chapman & Hall *by* J. Qarooni

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 421	Bakery and Confectionary Technology	✓	✓	✓	✓				✓				✓

FP 424 IT Applications in Food Industry 3 credits (3-0-0)

Objectives: To learn various applications of information technologies in food processing industry

Syllabus:

Importance of computerization and IT in food industry, operating environments and information systems for various types of food industries, principles of communication. Role of computer in Optimization. Introduction to Toolboxes useful to Food Industry; Curve fitting toolbox, Fuzzy logic toolbox, Neural Network toolbox, Image processing toolbox, statistical toolbox. Applications of CFD in Food and beverage industry. Introduction to CFD softwares. Introduction to Supervisory Control and Data Acquisition (SCADA); SCADA systems hardware and firmware SCADA systems software and protocols Landlines, Online food process control from centralized server system in processing plant. Introduction to MATLAB; MATLAB interactive sessions, computing with MATLAB; MATLAB help system, problem solving methodologies; Functions and Files in MATLAB, Programming using MATLAB, Program design and development, debugging MATLAB programs; Plotting and Model Building in MATLAB.

Recommended Books

1 Computer Applications in Food Technology: Use of Spreadsheets in Graphical, Statistical and Process Analysis by R. Paul Singh, AP. Published by Academic Press
2 Practical SCADA for Industry by David Bailey and Edwin Wright. Published by Elsevier
3 Introduction to MATLAB 7 for engineers by William J. Palm. Published by McGraw Hill Professional
4 Computation Fluid Dynamics in Food Processing by Da Wen Sun. Published by CRC press
5 Web Design: A Complete Introduction by Jenny Chapman. Published by John Wiley & Sons

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 424	IT Applications in Food Industry	✓	✓	✓	✓				✓				✓

FP 427 Food Business Management & Entrepreneurship Development 3 credits (3-0-0)

Objectives: To learn various aspects of Business management and entrepreneurship development in food processing

Syllabus:

Introduction and definitions related with project management and entrepreneurship; Fundamentals of project management and entrepreneurship development; Project formulation: market survey techniques, project identification, project selection, project proposal, work breakdown structure; Network scheduling: activity, networks, use of CPM, PERT in project scheduling. Resource planning, resource allocation, project scheduling with limited resources. Estimation of project costs, earned value analysis, project techno-economic viability, break-even analysis. Identification of business opportunity in food processing sector, Government policies for promotion of entrepreneurship in food processing. Launching and organizing an enterprise, enterprise selection, market assessment, feasibility study, SWOT analysis, resource mobilization. Financial institution in promoting entrepreneurship; Supply chain management.

Recommended Books

1. Management and Engineering by Gail Freeman Bell and James Balkwill. Printice Hall International
2. Entrepreneurship and Management inputs for entrepreneurs in Food Processing Sector by Dinesh Awasthi and Rama Jaggi

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 427	Food Business Management & Entrepreneurship Development	✓	✓	✓	✓				✓				✓

FP 430 Separation Techniques in Food Engineering 3 credits (3-0-0)

Objectives: To learn the fundamentals of various separation technologies applicable in Food Processing

Syllabus:

Introduction to various separation processes; Gas-Liquid, Gas-Solid, Liquid-Liquid, Liquid-Solid separation; Concept of phase equilibrium; Impingement separator; Electrostatic precipitation; Distillation-Application of distillation in food processing; Membrane separation technology – Introduction to micro-filtration, ultra-filtration, nano-filtration, reverse osmosis, electro dialysis; Physical characteristics of membrane separation; Factor affecting reverse osmosis process; Concentration of polarization; Design of reverse osmosis and ultra-filtration system; Operation layout of the modules; Electrodialysis; Pervaporization; Fabrication of membrane; Application of membrane technology in food industry. Powder Technology; Classification of powder; Separation of powder; Sieving; Air classification; Factor affecting air classification; Cyclone application; Air separation; Particle size distribution; Super critical fluid (SCF) extraction - Introduction; Properties of SCF; Food application of SCF; Application of SCFE in analytical technique and pharmaceutical application.

Text Books

1 Elements of Mass Transferring, PHI *by* Anantharaman N and Begum KMMS

2 Mechanical Operations for Chemical Engineers, Khanna Publisher *by* Narayanan CM and Bhattacharyya BC

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 430	Separation Techniques in Food Engineering	✓	✓	✓	✓				✓				✓

FP 433 Process Control and Instrumentation in Food Industry 3 credits (3-0-0)

Objectives: To learn process control and instrumentation in food processing industry

Syllabus:

Instruments for temperature, pressure, humidity measurements- types, calibration. Pressure gauge, basic concept of pneumatic pressure transmitter, pressure current and pressure resistance transducers. Positive displacement meter, Weight measurement- mechanical scale, electronic tank scale, conveyor scale, measurement of specific gravity, measurement of humidity, measurement of viscosity, measurement of density, automatic valves. Definition of process control, simple system analysis, dynamic behavior of simple process, Laplace transform, process control hardware. Frequency response analysis, frequency response characteristics, Bode diagram and Nyquist plots and stability analysis. Ionization techniques, scanning technique, application of GC/MS, LC/MS / FAB/MS /MS/MS and Linked scan techniques. Basic principles of chromatography. Paper chromatography, thin layer chromatography, HPLC (High performance liquid chromatography), Gas chromatography, Application in food analysis. Spectrophotometry introduction and principles- Atomic absorption spectroscopy. Electromagnetic spectrum – The NMR Phenomenon – Types of information provided by NMR spectra, NMR –application of NMR to Food analysis. Operating procedures and application in analysis of foods: FTIR, XRF, Differential Scanning Calorimeter, XRD, SEM, TEM, water activity, textural analyzer, e –sensors, biosensors, Nitrogen analyzers.

Recommended Books

1 The Chemical Analysis of Foods, Churchill Livingstone, New York *by* D. Pearson
2 Instrumental Methods of Chemical Analysis, Goel Publishing House, New Delhi *by* B. K. Sharma.

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 433	Process Control and Instrumentation in Food Industry	✓	✓	✓	✓				✓				✓

FP 434 Food Process Modeling and Simulation 3 credits (3-0-0)

Objectives: To learn application of modeling and simulations in food processing

Syllabus: Fundamentals of modeling and simulation; Definition of basic terms like system, entity attribute, activity, state of system, system environment; Different steps for modeling and simulation, Types of models; Advantages of modeling and simulation; Monte Carlo Method or random simulation, Application areas of simulation. Iterative convergence method, derivation and algorithm of bisectional method or intermediate value theorem; Regula Falsi method; Newton Raphson method, Generalized Newton's method for multiple roots, Iterative or method of successive approximation; Introduction to numerical integration, Simpson's 1/3rd rule, Solution of Ordinary Differential Equation Model: Picard Method, Taylor's Series method, Euler's method, Modified Euler's method, Runga Kutta method. Solution of partial differential equations models: Differential Laplace, Poisson, parabolic and hyperbolic equation, Finite difference method, graphical method, Bender - Schmidt method. Introduction to optimization, optimization methods, Graphical and numerical methods of optimization, Unconstrained and Constrained optimization, Programming optimization, experimental optimization, Response surface methodology (RSM). Modelling and simulation of selected food engineering operations.

Recommended Books

1 Computerized Control Systems in the Food Industry *by* Gauri S. Mittal
2 Computer aided techniques in Food Technology *by* Israel Saguy
3 Design of Experiments *by* Montgomery

Course Outcomes		POs											
		a	b	c	d	e	f	g	h	i	j	k	l
FP 434	Food Process Modeling and Simulation	✓	✓	✓	✓				✓				✓

DEPARTMENT OF MECHANICAL ENGINEERING

DETAILED SYLLABI OF COURSES

ME 170	Machine Drawing and Solid Modeling	0-0-3	2
ME 210	Design of Machine Elements	3-1-0	4
ME 211	Kinematics and Dynamics of Machinery	3-1-0	4
ME 213	Mechanics of Solids	3-1-0	4
ME 230	Primary Production Processes	3-1-0	4
ME 231	Total Quality Management	3-0-0	3
ME 250	Thermal Engineering	3-1-0	4
ME 251	Engineering Thermodynamics	3-1-0	4
ME 252	Thermal Problem in Electrical Systems	3-1-0	4
ME 253	Heat Transfer Problems in Electronics and Instrumentation	3-0-0	3
ME 254	Renewable Energy Systems	3-0-0	3
ME 256	The Quest for Absolute Zero	3-0-0	3
ME 271	Thermal Engineering Lab	0-0-3	2
ME 272	Mechanical Engineering Lab	0-0-3	2
ME 280	Machine Element Design Practice – I	0-0-3	2
ME 300	Finite Elements Analysis	3-0-0	3
ME 311	Composite Material	3-0-0	3
ME 313	Fundamentals of Ergonomics	3-0-0	3
ME 330	Metal Cutting and Tool Design	3-1-0	4
ME 331	Metal Machining and Automation	3-1-0	4
ME 332	Advanced Manufacturing Process	3-0-0	3
ME 333	Process Control and Assurance Science	3-0-0	3
ME 334	Surface Engineering	3-0-0	3
ME 335	Metrology and Computer Aided Inspection	3-0-0	3
ME 336	Plastic Part Manufacturing and Tool Design	3-0-0	3
ME 350	Heat Transfer	3-1-0	4
ME 351	Fluid Mechanics	3-1-0	4
ME 352	Fluid Dynamics and Hydraulic Machines	3-0-0	3
ME 353	Internal Combustion Engines	3-0-0	3
ME 354	Refrigeration and Air-conditioning	3-0-0	3
ME 355	Aircraft and Rocket Propulsion	3-0-0	3
ME 356	Turbo Machinery	3-0-0	3
ME 357	Gas Dynamics	3-0-0	3
ME 370	Heat Transfer and Refrigeration Lab.	0-0-3	2
ME 372	Fluid Mechanics & Fluid Machines Lab.	0-0-3	2
ME 373	Production Engineering Laboratory	0-0-3	2
ME 374	Computational Fluid Dynamics Lab.	0-0-3	2
ME 375	Internal Combustion Engines and Automobile Engineering Laboratory	0-0-3	2
ME 380	Production Engineering Project	0-0-3	2
ME 381	Machine Element Design Practice – II	0-0-3	2

ME 410	Advanced Mechanics of Solids	3-0-0	3
ME 411	Vibration and Noise Engineering	3-0-0	3
ME 412	Advanced Machine Dynamics	3-0-0	3
ME 413	Experimental Stress Analysis	3-0-0	3
ME 414	Mechatronics	3-0-0	3
ME 415	Fundamentals of Tribology	3-0-0	3
ME 416	Robotics	3-0-0	3
ME 417	Control System Engineering	3-0-0	3
ME 418	Material Handling	3-0-0	3
ME 430	Industrial Management	3-0-0	3
ME 431	Decision Modeling	3-0-0	3
ME 432	Non-Conventional Machining Processes	3-0-0	3
ME 433	Advanced Manufacturing Systems	3-0-0	3
ME 434	Computer Graphics for CAD/CAM	3-0-0	3
ME 435	Concurrent Engineering	3-0-0	3
ME 436	Entrepreneurship	3-0-0	3
ME 437	Welding Technology	3-0-0	3
ME 440	Industrial Management	3-0-0	3
ME 450	Computational Fluid Dynamics and Heat Transfer	3-0-0	3
ME 451	Power Plant Engineering	3-0-0	3
ME 453	Energy Conservation & Waster Heat Recovery	3-0-0	3
ME 455	Nuclear Power Generation and Safety	3-0-0	3
ME 457	Cryogenic Engineering	3-0-0	3
ME 470	Design Engineering Lab.	0-0-3	2
ME 480	Thermal Engineering Design Project	0-0-3	2
ME 481	Mechanical System Design Project	0-0-3	2
ME 483	Industrial Engineering Project	0-0-3	2

For B. Tech Courses (3 or 4 level) please refer to the B. Tech Curriculum and Syllabi, for M. Tech Courses (6 level) please refer to M. Tech Curriculum and Syllabi.

ME 170 MACHINE DRAWING AND SOLID MODELING 2 credits [0-0-3]

Drawing to be drawn manually: Projection of solids; Nut & bolt and Fasteners; Cotter joint; Plummer block; Expansion joint; Shaft coupling; Drawing to drawn using drafting software: Fundamentals of AutoCAD Mechanical Desktop, Dimension & annotations; Use of Layers; Working with constraint in dimension; Creating assembly; Axi-symmetrical parts; Creating surface features; Working with bill of material; Free hand sketches of commonly used parts are to be drawn and submitted to the teacher concerned in the sessional class.

Essential Reading:

1. K. L. Narayana, P. Kannaiah, K. Reddy, ***Machine Drawing,*** - New Age International, 2006.
2. ***AutoCAD Mechanical manual***, Autodesk Inc.

ME 210 DESIGN OF MACHINE ELEMENTS 4 credits [3-1-0]

Introduction to machine design, methodology, strength, rigidity, fracture, wear, and material considerations in design, use of standards, Selection of materials and processes. Standard numbering system including BIS designations of materials. concept of factor of safety. Application of theories of failure to design. Design of Riveted, Welded, Bolted joints, Power screw, shafts, keys and couplings, belt, rope and chain drives, journal bearing and antifriction bearings, springs, clutches and Gears.

Essential Reading:

1. J. E. Shigley and L. C. Mitchel, ***Mechanical Engineering Design - Tata Mc Graw-Hill***, 8th Ed, 2007.
2. P. C. Sharma, D. K. Agrawal, ***Machine Design*** –Kataria & sons, 2007.

Supplementary Reading:

1. M. F. Spotts, T. E. Shoup, ***Design of Machine Elements***, Pearson, 2003
2. R. C. Juvinal & K. M. Marshek ***Fundamentals of Machine Component Design*** - John Wiley, 2002.
3. Design Data Book – ***PSG College of Technology***, Coimbatore. 1995

ME 211 KINEMATICS AND DYNAMICS OF MACHINERY 4 credits [3-1-0]

Mechanisms: Lower and higher pairs, degrees of freedom, various types of mechanisms, their inversions and applications, Kinematics and structure diagrams, equivalent linkages, steering mechanisms. Motion analysis of planer mechanisms by graphical, analytical and computer aided methods instantaneous centre, Corioli's component of acceleration.; Cams: Cam follower systems, synthesis of roller cams, cam profiles, pressure angles,; Gears: Gearing terminology, spur, bevel, helical, worm, gears, motion and synthesis of simple, reverted and epicyclic gear trains, gear corrections.; Kinematic synthesis: Classical synthesis techniques, Analytical synthesis of four line mechanisms and planner mechanisms. Dimensional synthesis, three position synthesis for function generation, path generation.; Dynamics: Review of planar rigid & body dynamics, static and dynamic analysis of mechanisms, slider crank and quick return motion mechanism dynamics.; Balancing: Static and dynamic balancing of rotors, balancing of single cylinder, multi cylinder, inline, radial & V-engines. Dynamics of Flywheels, Cams & Gyroscopes.

Essential Reading:

1. J. E. Sigley & J. J. Ucker, ***Theory of Machines and Mechanisms*** - McGraw Hill.
2. A. Ghosh & A. K. Mallick, ***Theory of Mechanisms and Machines*** - McGraw Hill.

ME 213 MECHANICS OF SOLIDS 4 credits [3-1-0]

Definition of stress, stress tensor - normal and shearing stresses in axially loaded members. Normal and shearing strains - stress-strain relationship - Generalized Hooke's Law - Poisson's ratio - relationship between material properties of isotropic materials. - stress-strain diagram for uniaxial loading for ductile and brittle materials - working stress - factor of safety. Composite bars in tension and compression, temperature stresses, statically indeterminate problems. Thin Cylinders and Spherical Shells, Torsion of Circular Shafts and Helical Springs**,** shear force and bending moment diagrams, pure bending theory, shearing stresses in beams, Deflection of Beams, Theory of Columns, Plane stress and plane strain problems, Energy methods: Strain energy due to axial, torsion, bending and transverse shear. Castigliano's theorem, reciprocity theorem, Theories of Failure.

Essential Reading:

1. S. P. Timoshenko and D. H. Young, ***Elements of Strength of Materials*** - Affiliated East West Press Pvt. Ltd.
2. E. P. Popov, ***Engineering Mechanics of Solids*** - Prentice Hall India, New Delhi. 1990.

Supplementary Reading:

1. I. H. Shames, ***Introduction to Solid Mechanics*** - Prentice Hall of India, New Delhi. 1989.
2. G. H. Ryder, ***Strength of Materials*** - ELBS.

ME 230 PRIMARY PRODUCTION PROCESS 4 credits [3-1-0]

Foundry : Introduction to patterns and foundry process, Sand binders and different additives, Sand testing and melting furnaces for ferrous and non-ferrous metals such as cupola, Induction furnace, Arc furnace & Resistance Furnace. Solid fiction of castings, Continuous casting process: Precision investment casting, centrifugal casting, Die casting, Casting defects.; Welding and cutting: Introduction to gas welding, cutting, Arc welding and equipment's. TIG (GTAW) and MIG (GMAW) welding, resistance welding and thermit welding. Weldability, Newer Welding methods like plasma Arc, Laser Beam, Electron Beam, Ultrasonic, Explosive and friction welding. Brazing and soldering, welding defects. Destructive and non-destructive testing of castings and weldings.; Brief introduction to powder metallurgy processes.; Plastic deformation of metals: Variables in metal forming and their optimization. Dependence of stress strain diagram on Strain rate and temperature. Hot and cold working of metals.; Rolling: Pressure and Forces in rolling, types of rolling mills, Rolling defects.; Forging: Smith Forging, Drop and Press forging, M/c forging. Forging defects.; Extrusions, Direct, Indirect, Impact and Hydrostatic extrusion and their applications. Extrusion of tubes. Wire drawing methods and variables in wire-drawing. Optimum die shape for extrusion and drawing.; Brief introduction to sheet metal working: Bending, Forming and Deep drawing.

Essential Reading:

1. P. C. Mukherjee, ***Fundamentals of metal casting technology***, Oxford and IBH.
2. B. Ravi, ***Design of Metal Casting*** - PHI.
3. H. Choudhury, ***Workshop Technology – Vol –I & II***, Media Promotion & Publisher Pvt. Ltd.

ME 231	TOTAL QUALITY MANAGEMENT	3 credits [3-0-0]

An Overview: Quality Definition, Quality, Price, Value Relationship, Hardware and Software Aspects of Quality. Quality Philosophies: Deming's 14 Points, Juran's Trilogy, Crosby's Zero Defect, Ishikawa diagram. Quality Costs: Prevention, Appraisal, Internal Failure, External Failure. Total Quality Management: Concept, Comparison with Traditional Quality, Implementation of TQM, Malcolm Baldridge Award, TQM in Education. Kaizen: Concept of Waste Elimination, Various Forms of Waste, Various Causes of Waste, Kaizen Approach, Kaizen Benefits. Quality Systems: ISO 9000. Benchmarking, Business Process Re-engineering, Tools (old) & 7 Tools (new)

Essential Reading:

1. Dr. K. C. Arora, ***TQM and ISO 14000***, S. K. Kataria & Sons, New Delhi.
2. A. Feigenbaum, ***Total Quality Control***, McGraw Hill

ME 250	THERMAL ENGINEERING	4 credits [3-1-0]

Laws of perfect gas; gas constants, concept of system, surrounding, equilibrium, Heat and work transfer, quasi-static process, temperature and Zeroth law of thermodynamics. Units & Dimensions; First Law of Thermodynamics: Internal energy, enthalpy, 1st law applied to non-flow and steady flow processes; Second Law: Clausius and Kelvin-Plank statements, Carnot cycle, corollaries, entropy, changes of entropy or a perfect gas in various processes. Properties of Pure Substances: Definitions, p-V, p-T, T-s and his diagrams for a pure substance, quality, Steam Tables, Charts for thermodynamics properties, Measurement of steam quality; Vapour Power Cycles: Rankine cycle, Comparison of Rankine and Carnot vapor cycles, Regenerative cycles, Ideal working fluid for vapor power cycles, Binary vapor cycle, Thermodynamics of couples cycles, Process heat and by-product power; I. C. Engines: Air standard Otto, Diesel and Dual cycles, C. I. and S. I. engines; Four stroke and two stroke cycles, Indicated Power, Brake Power, Mechanical, Thermal and relative efficiencies. Valve timing Diagram, fuel supply system; Air compressors and Motors: working principles of reciprocating air compressors, volumetric efficiency, effect of clearance, single and multistage compressors with intercooling, optimum inter-stage pressure, air motors and other application of compressed air.

Essential Reading:

1. P. K. Nag, ***Engineering Thermodynamics***, TMH.

ME 251	ENGINEERING THERMODYNAMICS	4 credits [3-1-0]

Basic concepts, thermodynamic equilibrium and quasi-static processes, Zeroth law of thermodynamics; Energy Interactions: displacement and other types of work, free expansion, Heat transfer; First Law of Thermodynamics: First law for a closed system, Energy - a property of the system, Different forms of stored energy, enthalpy, First law applied to flow processes; Second Law of Thermodynamics: Qualitative difference between heat and work, Heat Engines, Refrigerators and Heat pumps, Kelvin-Plank and Clausius statements of second law and their equivalence, Reversibility and irreversibility, Ideal processes, Carnot Cycle, Corollaries of second law, Carnot's theorem, Absolute thermodynamic temperature scale, Clausius inequality; Entropy: Definition, Principles of increase of entropy, calculation entropy for various processes; Available Energy and Availability: Helmholtz and Gibbs functions, Availability in steady flow, Entropy equation for flow processes, irreversibility; Properties of Pure Substances: p-V, p-T, T-s and h-s diagrams for a pure substance, quality, Steam Tables and charts for thermodynamics properties, Measurement of steam quality; Properties of Gases and Gas Mixtures: equation of state, Calculation of property changes for ideal gases, Real gases definition and equations of state, Law of corresponding states, Gas mixtures and Dalton's Law; Combined 1st and 2nd Laws: Maxwell relations, T-dS equations, Joule-Kelvin effect, Clausius-Clapeyron equation, Gibb's Phase rule and Conditions of stability; Reciprocating air compressors: Work required for single and multistage air compressors, Effect of intercooling, Optimum interstage pressure, Effect of clearance on volumetric efficiency, Air motors.

Essential Reading:

1. Jones and Hawkins, ***Engineering Thermodynamics***, John Wiley.
2. V. Wylen and Sonntag, ***Fundamentals of Classical Thermodynamics***, John Wiley.
3. Kadambi and Prasad, ***An Introduction to Energy Conversion*** (Vol. I & II), Wiley Eastern.

ME 252 THERMAL PROBLEMS IN ELECTRICAL SYSTEMS 4 credits [3-1-0]

Fundamentals of thermodynamics: Concept of system, surrounding, state, process and equilibrium, Temperature and Zeroth law of thermodynamics.; First and second law of thermodynamics: First and second law analysis, Concept of internal energy, enthalpy and entropy.; Heat Transfer: Fundamental modes of heat transfer-Conduction, Convection and Radiation. Effectiveness of a fin and its efficiency, Introduction to forced and natural convection, Surface radiation.; Properties of Pure Substances: Definitions, p-V, p-T and T-s diagrams for pure substance, Properties of substances from Steam tables.; Power Plant Engineering: Rankine cycle, procdure for improving the efficiency of the Rankine cycle, Regenerative cycle; Heat transfer in Transformers; air cooling and oil cooling, cooling of motor windings, cooling of electrical panels (control room)

Essential Reading:

1. P. K. Nag, ***Engineering Thermodynamics*** –Tata McGraw-Hill.
2. Y. A. Çengel and M. A. Boles, ***Thermodynamics: An Engineering Approach*** –MGraw-Hill.

Supplementary Reading:

1. P. K. Nag, ***Power Plant Engineering*** –Tata Mc. Graw Hill.
2. P. L. Ballany, ***Thermal Engineering*** –Khanna Publishers.
3. R. K. Rajput, ***A text book of Electrical Technology*** –laxmi Publications.
4. M. N. Ozisik, ***Heat Transfer: A Basic Approach*** –McGraw-Hill.
5. R. K. Rajput, ***Thermal Engineering*** –Laxmi Publications

ME 253 HEAT TRANSFER PROBLEMS IN ELECTRONICS AND INSTRUMENTATION 3 credits [3-0-0]

Fundamentals of Thermodynamics: Concepts and definitions, 1st law and its analysis for open and closed system, 2nd law: Kelvin-Plank and Claussius statements, Introduction to entropy. Fundamental modes of heat transfer: Conduction, Convection and Radiation.; Conduction: Fourier law, Problem formulation, Boundary conditions, 1-D temperature solution, Lumped system analysis, Heat transfer through extended surfaces (fins), Efficiency and effectiveness of fins. Design of fin geometry and optimum spacing of fins in a device, Heat transfer from fin surface of variable cross section. Convection: Forced and natural convection through flat plate and duct. Heat transfer coefficient correlations for laminar and turbulent convection. Radiation: Stefan law, emissive power, emissivity and reflectivity, equivalent heat transfer coefficient for combined convection and radiation.; Applications: Heat sink, Electronic chip cooling, Temperature measurement: static and dynamic characteristics of temperature sensors.

Essential Reading:

1. M. N. Ozisik, ***Heat Transfer: A Basic Approach*** –McGraw-Hill.
2. P. K. Nag, ***Engineering Thermodynamics*** –Tata McGraw-Hill.

Supplementary Reading:

1. Y. A. Cengel, ***Heat Transfer: A Practical Approach*** –McGraw-Hill.
2. S. P. Sukhatme, ***A Text Book on Heat Transfer*** –University Press (Fourth Edition).
3. F. P. Incropera, D. P. DeWitt, T. L. Bergman, A. S. Levine, ***Introduction to Heat Transfer*** –Wiley.

ME 254 RENEWABLE ENERGY SYSTEMS 3 credits [3-0-0]

Solar Energy: Solar Radiation: Solar thermal process, heat transfer devices, solar radiation measurement, estimation of average solar radiation. Solar energy storage: stratified storage, well mixed storage, comparison, Hot water system, practical consideration, solar ponds, Non-convective solar pond, extraction of thermal energy and application of solar ponds.; Other Renewable Energy Systems: Wind energy: The nature of wind. Wind energy resources and modeling. Geothermal energy: Origin and types of geothermal energy and utilisation. OTEC: Ocean temperature differences. OTEC systems. Wave energy: Fundamentals. Availability. Wave-energy conversion systems. Tidal energy: Fundamentals. Availability. Tidal-energy conversion systems. Energy from biomass: Photosynthesis. Biomass resource. Utilisation of biomass.

Essential Reading:

1. S. P. Sukhatme, ***Solar Energy Principle of Thermal Collection and Storage***, TMH, 1990.
2. Gary L. Johnson, 1985, ***Wind Energy Systems***, Prentice Hall Inc. New Jersey.
3. J. M. Kriender, ***'Principles of Solar Engineering'***, McGraw Hill, 1987.

Supplementary Reading:

1. V. S. Mangal, ***Solar Engineering***, TMH, 1992.

2. N. K. Bansal, ***Renewable Energy Source and Conversion Technology***, TMH, 1989.
3. P. J. Lunde, ***Solar Thermal Engineering'***, John Willey, 1988.
4. J. A. Duffie and Beckman W. A., ***Solar Engineering of Thermal Processes***, Wiley, 1990.

ME 256 THE QUEST FOR ABSOLUTE ZERO 3 credits [3-0-0]

Electrical and thermal properties of solids at extreme low temperature; Debye theory for specific heat of solids; Third law of Thermodynamics. Properties of liquid helium, Phase transition, Lambda point, super fluidity. Thermodynamic principles of refrigeration, Kapitza and Collins cycles for liquefaction of helium, Modeling and optimization of cryogenic cycles for refrigerators and liquefiers; Refrigeration with Helium – 3.; Refrigeration below 1 Kelvin, Magnetic refrigerators, dilution refrigerator; Pomeranchuk cooling.; Regenerative cycles – Stirling, GM and Pulse tube; Regenerator materials for deep low temperature refrigerators.; Extreme low temperature; Introduction to statistical mechanics in extreme low temperature physics.

Essential Reading:

1. K. Mendelssohn, ***The Quest for Absolute Zero: The meaning of low temperature physics***, Wiley, 1977
2. T. Frederking, SWK Yuan, ***Cryogenics-Low Temperature Engineering & Applied Sciences***, Yutopian Enterprises (December 15, 2005),
3. M. W. Zemansky, R. H. Dittman, ***Heat and Thermodynamics*** (Hardcover), McGraw-Hill.

ME 280 MACHINE ELEMENT DESIGN PRACTICE – I 2 credits [0-0-3]

Design and drawing of boiler (pressure vessels); Design and drawing of bolted joints; Design and drawing of welded joint; Design and drawing of cotter and knuckle joint; Design and drawing of flexible coupling; Design and drawing of universal coupling; Design and drawing of screw jack; Deign and drawing of belt/chain drive; Design and drawing of fly wheels; Design and drawing of cams.

ME 300 FINITE ELEMENTS ANALYSIS 3 credits [3-0-0]

Introduction, brief history of development, advantages, disadvantages of finite element analysis, basic steps and limitations, error and accuracy in finite element analysis, structural stiffness and network analysis, assembly and analysis of a structure, finite element analysis of an elastic continuum, displacement approach, minimization of total potential energy, convergence criteria, generalization of finite element concepts, alternative approach to finite element formulation, plane stress and plane strain analysis, element characteristics, triangular, rectangular and isoparametric elements, some practical applications, axisymmetric stress analysis, some illustrative examples, computer methods and computer programmes, data input, stiffness generation, assembly and solution of equations and output of results, application of FEM to structural, plastic deformation, fluid flow and heat transfer problems, FEM software packages, modeling capabilities, preprocessors and postprocessors, modern trends in finite element analysis.

Essential Reading:

1. ***Schaum's outline of Finite Element Analysis***, MGH 2008.
2. ***Finite Element Analysis*** by University Press, 2004.

Supplementary Reading:

1. O. C. Zienkiewicz, ***The Finite Element Method in Engg Science***, TMH, 2006.
2. S. S. Bhavikati, ***Finite Element Analysis***, New Age, 2005.

ME 311 COMPOSITE MATERIAL 3 credits [3-0-0]

Definition and Classification of Composites, MMC, PMC, CMC. Reinforcing fibres- Natural fibres (cellulose, jute, coir etc), boron, carbon, ceramic glass, aramids, polyethylene (UHMWPE), polybenz-thiazoles etc. Particulate fillers-importance of particle shape an size. Matrix resins-thermoplastics and thermosetting matrix resins. Coupling agents-surface treatment of fillers and fibres, significance of interface in composites. Nanocomposites, short and continuous fibre reinforced composites, critical fibre length, anisotropic behaviour, SMC, BMC, DMC etc. Fabrication techniques pultrusion, filament winding, prepreg technology, injection and compression moulding, bag moulding, resin transfer moulding, reaction injection moulding. Properties and perfor mance of composites. Applications.

Essential Reading:

1. K. K. Chawla, ***Composite Materials – Science & Engineering***, Springer-Verlag, New York, 1987.
2. F. L. Matthews and R. D. Rawlings, ***Composite Materials: Engineering and Science***, Chapman & Hall, London, 1994.

3. Dr N. Chand, ***Tribology of Natural fiber Composites***, Wood Head Publishing Limited, England

ME 313	FUNDAMENTALS OF ERGONOMICS	3 credits [3-0-0]

Objective : To develop awareness, acquire information, and experience human factors in design. Datalogging, data collection, data reduction and data analysis techniques. Gross human anatomy, anthropometry, biomechanics, muscle strength and exertion potential of different limbs, work capacity, environmental effects. Exercises for evaluation of postural forms and work spaces. Environmental conditions including temperature, illumination, noise and vibration. Perception and information processing, design of displays, hand controls, typography and readability, layout and composition. Exercises in evaluation of human response to product interface. Product safety and products liability.

Essential Reading:

1. D. C. Alexgander, ***Applied Ergonomics*** - Taylor and Francis

ME 330	METAL CUTTING AND TOOL DESIGN	4 credits [3-1-0]

Geometrical parameters of cutting tool edges and their effect on tool force and power consumption, Mechanics of chip formation at low and high cutting speeds. Orthogonal and oblique cutting; Controlled contact cutting, Shear angles, Force and velocity relationships, Cutting forces in turning; Planning, Drilling and milling operations, controlled Contact Cutting, Chip-Breaking Effect, stress-distibution; Types of Tool Wear: Flank wear, Crater wear, Wear measurement, Cutting fluid and its effect; Machinability Criteria, Tool life and Taylor's equation, Effect of variables on tool life, and surface finish, Tool-life test; Economics of Machining, Economic tool life, Gilbert's Model.; Introduction to cutting tool materials, types of cutting tools, design of single point cutting tool, form tool, broach; Introduction to micro-machining, diamond turning, micro-turning, micro-drilling, micro-milling, hybrid-micromachining, micro-edm, micro-ecm, micro-wedm, micro-wedg; Sheet-metal working, blanking and piercing, compound and progressive die; Principles of location and clamping, design of drilling jig and fixture for milling, broaching, turning; Design of forging die block, drop forging and upsetting.

Essential Reading:

1. Bhattacharyya, ***Metal Cutting Theory and Practice*** - Central Book Publishers, Calcutta 2000.
2. Lecain, Goold, ***Tool Design – Donaldson***, TMH, New Delhi. 2004

Supplementary Reading:

1. Arshinov, ***Metal cutting Theory Design*** - Mir Publisher
2. P. C. Sharma, ***A Text Book of Production Engineering*** - S. Chand & Co.

ME 331	METAL MACHINING AND AUTOMATION	4 credits [3-1-0]

Principles of machine tools: Kinematics of machine tools, speed transmission from motor to spindle, Speed reversal mechanism, Tool holding and job holding methods in different M/C tools, Types of surfaces generated, Indexing mechanism and thread cutting mechanism. Concepts of Aesthetic and Ergonomics applied to machine tools, Acceptance tests and Standardisation of machine tools, Machine tool reconditioning. Latest trends in machine tool design; Non-Conventional metal removal process : Electro Discharge Machining, Laser Beam, Plasma Arc, Ion Beam, Electro Chemical, Abrasive jet, Ultrasonic and water jet-machining.; Numerical control: Brief principles and description of numerical control application to M/C tools. DNC, CNC and adaptive control. Programming of CNC M/C tools, CNC programming based on CAD.; Fundamentals of CAD/CAM, Computer integrated manufacturing, Compute Aided Process Planning, Computer Integrated Production Planning system.; Flexible Manufacturing Systems: types, Benefits and Elements of FMS Applications of FMS.; Robotics: Definition, Types and programming of Robots, Application of Industrial robots.

Essential Reading:

1. H. Choudhury, ***Workshop Technology – Vol –II***, Media Promotion & Publisher Pvt. Ltd.
2. ***Production Technology*** – HMT-TMH.
3. P. C. Pandey and H. S. Shen, ***Modern Machining process***.
4. G. C. Sen & A. Bhattacharya, ***Principles of M/c Tools*** –New Control Book Agency.
5. M. P. Grover, ***Automation Production system and Computer Integrated Manufacturing*** –PHI.

Supplementary Reading:

1. Radhakrishnan & Subramanium, ***CAD, CAM, CIM*** - New Age India Publisher Pvt., Ltd.
2. Bhattacharya, ***Metal cutting theory & Practice*** –New control Book Agency.
3. N. K. Meheta, ***Machine Tool Design*** - TMH.

4. G. C. Sen and A. Bhattacharya, ***Principles of Machine Tools*** - New Central Book Agency.
5. R. K. Mittal & I. J. Nagrath, ***Robotics and Control*** - TMH.
6. P. N. Rao, ***CAD/CAM***, Principles and Applications - TMH.

ME 332 ADVANCED MANUFACTURING PROCESSES 3 credits [3-0-0]

Surface engineering and High speed grinding: Application of advanced coatings in high performance cutting tools and high performance super-abrasive grinding wheels. Application of surface coating in metal-ceramic joining. Ultra high speed grinding with monolayer CBN grinding wheel. Machining and grinding under cryogenic environment. Micro and nano machining of glasses and ceramics in ductile regime using diamond cutting tool and diamond grinding wheel.; Theory and application of chemical processing: Chemical Machining, Aching of semi conductors, Coating and Electroless forming and CVD.; Rapid prototyping: Need for Rapid Prototyping, Basic Principles and advantages of RP, Classifications of different RP techniques with examples, Introduction to three Representative RP techniques: Fused deposition; modeling. Laminated Object Manufacturing and Stereo-lithography.; MEMS: Introduction, history, development and need of micro-electro-mechanical systems. IC fabrication processes used for MEMS; MEMS sensors and actuators; Mechanical Process techniques and process models for micro-machining; Fabrication processes and design of the process sequences; Agile prototyping; Reliability and process control of micro manufacturing processes' Introduction to nano-technology processes.; Concurrent Engineering: Product development cycle, Sequential Engineering versus Concurrent Engineering, Implementation of Concurrent Engineering, Concurrent Engineering and Information Technology, Soft and Hard Prototyping, Characteristics of Concurrent Engineering Key factors influencing the success of CE.

Essential Reading:

1. ***Surface Wear Analysis, Treatment & Prevention*** - ASM Inernational, Materials Park, OH, U. S. A., 1st Ed. 1995
2. ***Advanced Thermally Assisted Surface Engineering*** - Kluwer Academic Publisher, MA, USA, 2nd ed. 2002.
3. P. Radhakrishnan, ***CAD/CAM/CIM*** - New Age International Publishers., 4th ed. 2001

ME 333 PROCESS CONTROL AND ASSURANCE SCIENCE 3 credits [3-0-0]

METROLOGY: Line and End Standards, Principles of Measurements, Calibration, Accuracy and Precision; Measurement of Surface Roughness, Screw, Thread and Gears; Limits, Fits and Gauges, Assembly by full, partial and group interchangeability, geometric tolerances; QUALITY ASSURANCE: Some useful Probability Distribution, Testing of hypothesis, type I and type II errors, control limit theorem. Taguchi's Loss function, Orthogonal Arrays, Linear Graphs, parametric design, signal-to-noise Ratio, ANOVA. Causes of Variation, standard error of mean, process capability, PCR, RPI, Natural tolerance Limits, Specification Limits, Trial and Revised control Limits, Rational subgroups, Control charts for variables (X-bar, R, S, CUSUM, EWMA), Control charts for fraction non-conforming, control charts for non-conformation. Design of single sampling plan. Double, multiple and sequential sampling plans, O. C. curve, AOQ, AOQL, ATI, AFI, ASN MIL-STD 105D tables, switching rules. Neural network application in quality control; RELIABILITY: Definition, bath-tub-curve, system reliability, reliability improvement, maintainability and availability, Availability of single repairable system using Markov model, Life tests, Acceptance sampling plan based on life tests, Sequential acceptance sampling plan based on MTTF.

Essential Reading:

1. M. R. Taher, ***Metrology, Measurement and Measuring Instruments***, RNLBP, Allahabad.
2. A. Mitra, ***Fundamentals of Quality Control and Improvement***, 2nd Edn, PHI, New Delhi.

ME 334 SURFACE ENGINEERING 3 credits [3-0-0]

Philosophy of surface engineering, general applications and requirements; Corrosion Processes: Basic principles of electrochemistry and aqueous corrosion processes; pitting, crevice and exfoliation corrosion; influence of deposits and anaerobic conditions; corrosion control; high temperature oxidation and hot corrosion; corrosion/mechanical property interactions; Friction and Wear: Abrasive, erosive and sliding wear. The interaction between wear and corrosion; Analytical Techniques: X-ray diffraction, TEM, SEM and WDP analysis, surface analysis by other techniques; Surface Engineering: Philosophy; surface engineering as part of a manufacturing process; integrating coating systems into the design process; Coating Manufacture: Electro deposition; flame and plasma spraying; physical vapor deposition; chemical vapor deposition; surface treatments; paint and paint systems; Applications: Coating systems for corrosion and wear protection; new coating concepts including multi-layer structures, functionally gradient materials, intermetallic barrier coatings and thermal barrier coatings.

ME 335 METROLOGY & COMPUTER AIDED INSPECTION 3 credits [3-0-0]

Metrological concepts - Abbe's principle - need for high precision measurements - problems associated with high precision measurements. Standards for length measurement - Shop floor standards and their calibration – Light interference - Method of coincidence - Slip gauge calibration - Measurement errors. Various tolerances and their specifications, gauging principles, selective assembly, comparators. Angular measurements - principles and instruments. Gear and Thread measurements. Surface and form metrology - flatness, roughness, waviness, roundness, cylindricity, etc. Computer Aided Metrology - Principles and interfacing, software metrology. Laser metrology - Applications of Lasers in precision measurements - Laser interferometer, speckle measurements, laser scanners. Coordinate Measuring Machine - Types of CMM - Probes used - Applications - Non contact CMM using Electro optical sensors for dimensional metrology - Non contact sensors for surface finish measurements. Image processing and its application in Metrology.

Essential Reading:

1. D. M. Anthony, ***Engineering Metrology***, Pergamon Press.
2. G. G. Thomas, ***Engineering Metrology***, Butterworth.

ME 336 PLASTIC PART MANUFACTURING AND TOOL DESIGN 3 credits [3-0-0]

Fundamentals of Polymer Technology; Properties of Solid and Molten Polymers; Selection of Materials and Manufacturing Methods; Extrusion Equipment and Processing techniques; Injection Moulding; Blow Moulding, Rational Moulding, Compression and Transfer Moulding, Thermoforming; Resin Transfer Moulding; Rapid Prototyping and Tooling processes. Other Manufacturing methods (Machining, Joining, Finishing, Assembly) CAD/CAM of Dies/ Moulds/Tools; Flow analysis. Typical defects in plastic components and their prevention.

Essential Reading:

1. P. A. Tres, ***Designing Plastic Parts for Assembly***, Hanser Gardner Publications; 5th edition, 2003
2. R. A. Malloy, ***Plastic Part Design for Injection Molding:*** An Introduction, Hanser Gardner Publications, 1994.
3. J. Rotheiser, ***Joining of Plastics: Handbook for Designers and Engineers***, Hanser Gardner Publications, 2004
4. J. P. Beaumont, R. Nagel, R. Sherman, ***Successful Injection Molding: Process, Design, and Simulation***, Hanser Gardner Publications, 2002

ME 350 HEAT TRANSFER 4 credits [3-1-0]

Modes of Heat Transfer, Combined heat transfer mechanism, Analogy between flow of heat and electricity, Conduction: Three dimensional Fourier conduction equation in Cartesian coordinates, One-dimensional steady conduction through slab, cylinder, Sphere and composite medium, Critical insulation thickness, Effect of variable thermal conductivity. Heat transfer through rectangular and pin fins. Fin effectiveness and Fin efficiency, Fin arrangement. Introduction to two-dimensional steady heat condition, Analytical methods for solving two-dimensional heat conduction problems; Convection: Hydrodynamics and thermal boundary layers for laminar flow over a flat plate. Integral solution of boundary layer equations for laminar flow over a flat plate. Heat transfer for laminar flow in tubes, heat transfer in turbulent flow, Reynolds analogy. Laminar free convection boundary layers equations for flow over a vertical plate. Dimensional analysis applied to forced and free convection. Boiling and Condensation: Film and drop wise condensation, Nusselt's theory of laminar film condensation, Pool boiling regimes, Rohsenow correlation for nucleate boiling; Radiation: Black body and monochromatic radiation, Total emissive power, Stefan-Boltzmann law, Grey body Kirchoff's law, Wien's displacement law, Radiation between two black bodies, Shape factors for simple geometries, Radiation between two grey bodies, Electrical network method for solving radiation problems, Radiation shields; Heat Exchangers: Types, Overall heat transfer coefficient, Fouling factors, Logarithmic mean temperature difference, Effectiveness, Number of transfer units, Heat exchanger Design.

Essential Reading:

1. Gupta and Prakash, ***Engineering Heat Transfer***, Nemchand.
2. J. P. Holman, ***Heat Transfer,*** TMH
3. M. N. Ozisik, ***Heat Transfer - A Basic Approach***, McGraw Hill

ME 351 FLUID MECHANICS 4 credits [3-1-0]

Introduction: Physical properties of fluids, Ideal and Real fluids, Concept of shear stress, Newtonian and Non-Newtonian fluids. Fluid Statics: Pressure-density-height relationships, Manometers, Force on plane and curved surfaces, Centre of pressure, Buoyancy, Stability of immersed and floating bodies. Fluid masses subjected to uniform accelerations, Free and forced vortex. Fluid Kinematics: Steady and unsteady, uniform and non-uniform, laminar and turbulent flows. Free surface flows and enclosed flows. Definition of one-, two- and three-dimensional flows. Stream lines, Streak lines, Path lines. Stream tubes. Stream function and velocity potential. Flow nets. Fluid Dynamics: Equation of continuity. One-dimensional Euler's equation of motion and its integration to obtain Bernoulli's equation and momentum equation. Flow through pipes (incompressible flow): Laminar and turbulent flow in pipes, Hydraulic mean radius, Darcy -Weisbach equation, Moody's diagram. Minor losses, Pipes in parallel and series. Transmission of power. Water hammer in pipes. Measurements: Pitot tube, Current meter, Venturi meter, Orifice meter, Orifice and mouthpieces, Notches and Weirs.

Essential reading:

1. S. K. Som and G. Biswas, ***Fluid Mechanics and Fluid Machines,*** Tata McGraw-Hill.
2. B. S. Massey, ***Mechanics of Fluids*** by ELBS.

Supplementary reading:

1. K. Mohanty, ***Fluid Mechanics***, Prentice Hall.
2. R. J. Garde and A. C. Mirajgackar, ***Engineering Fluid Mechanics*** by Nem Chand Bros.
3. K. L. Kumar, Fluid Mechanics, S. Chand Co.

ME 352 FLUID DYNAMICS & HYDRAULIC MACHINES 3 credits [3-0-0]

Boundary layer growth over a flat plate, Boundary layer thickness, Displacement thickness, Momentum thickness and energy thickness, Laminar and turbulent boundary layer, Momentum integral equation, Separation of boundary layer flow. Drag and lift, pressure drag and friction drag, stream lined body and bluff body, Drag over a flat plate, Drag characteristics of sphere and cylinder, Lift and Magnus effect, Lift characteristics of air foils.

Dimensional homogeneity, Dimensional Analysis, Rayleigh's method and Buckingham theorem. Similarity laws and model studies. Forces on fixed and moving flat plates and curved plates, work done and efficiency. Turbines: Classification, Study of Pelton, Francis and Kaplan Turbines, Blade Angle, Velocity Triangle, Efficiencies. Specific speed unit quantities, Performances of turbines, Principle of similarity applied to turbines. Centrifugal Pumps: Principle and Classification, Efficiency, Specific speed, Characteristic curves, Multi stage pumps, Pumps in series and parallel, Principle of similarity applied to pumps, cavitation in pumps, NPSH. Reciprocating Pump: Principle of working, Slip, Work done, Effect of acceleration and frictional resistance, Separation, Air vessels. Miscellaneous Machines: Rotary and air injection pumps, Hydraulic ram, Hydrostatic machines, Fluid power transmission systems, Hydraulic accumulator, Intensified, Press and Jack.

Essential Reading:

1. Dr. J. Lal, ***Hydraulic Machines - Metropolitan Book Co***, New Delhi.
2. S. K. Som and G. Biswas, ***Fluid Mechanics and Fluid Machines***, Tata McGraw-Hill.
3. B. S. Massey, ***Mechanics of Fluids***, ELBS.

Supplementary Reading:

1. K. Mohanty, ***Fluid Mechanics***, Prentice Hall.
2. V. P. Vasandani, ***Hydraulic Machines*** - Khanna Publishers.
3. 3. K. L. Kumar, ***Fluid Mechanics*** by S. Chand Co.

ME 353 INTERNAL COMBUSTION ENGINES 3 credits [3-0-0]

Introduction to I. C Engine-Classification-Components-Air standard cycles, characteristics of fuel air mixtures, variation of specific heats-Actual cycles, actual processes taking place in engines-Importance of Port, Valve timing diagram; Carburetion and fuel injection: Requirements of a good carburetor, simple carburetor, complete carburetor, Calculation of air-fuel ratio for a simple carburetor. Electronic fuel injection in S. I. engine. Requirements of diesel injection system, types of injection systems, fuel pumps. Ignition systems; Combustion in S. I. Engine and C. I. Engines: Stages of combustion in S. I. Engine, Detonation, Control of detonation. Stages of combustion in C. I. Engines, delay period, factors; Various systems of I. C. Engine, Lubrication system, function of lubricating system. Cooling system etc.; Testing and performance: Variable speed test of S. I. Engine, Constant speed load tests of C. I. Engines Morse tests; Engine Emissions-Pollutants and their ill effects, pollutants from Gasoline and diesel. Supercharging and turbo charging.

Essential Reading:

1. J. B Heywood, ***Internal Combustion Engine Fundamentals***, McGraw Hill
2. V. Ganesan, ***Internal Combustion Engines***, McGraw Hill Company, (1992).
3. M. L. Mathur and R. P Sharma, ***A Course in internal combustion engines***, Dhanpat Rai and Sons, (1980).

4. Newton and Steed: ***Automobile Engineering***, ELBS Publishing, (1978).
5. G. B. S Narang, ***Automobile Engineering***, Dhanpat Rai and Sons, (1988).
6. K. K. Ramalingam, ***Internal Combustion Engine Fundamentals***, Scitech Publications.

ME 354 REFRIGERATION AND AIR-CONDITIONING 3 credits [3-0-0]

Refrigerants: Classification of Refrigerants, Halocarbon compounds, Azeotropes, Hydro-carbons, Inorganic compounds, Properties of refrigerants, Comparison of common refrigerants, Uses of important refrigerants, Brines, Ozone friendly refrigerants.; Vapor Compression Systems: Analysis of Theoretical vapor-compression cycle, Unit of refrigeration, Coefficient of performance, T-S and P-H diagram, Simple Saturated cycle, Subcooled cycle and superheated cycle, Effect of suction and discharge pressure on performance, Actual vapor-compression cycle.; Multistage compression and multi-evaporator systems Different arrangements of compressors and inter cooling, Multi-stage compression with intercooling, Multi-evaporator system, Dual compression system; Vapor-Absorption system: Simple Ammonia-absorption system, Improved absorption system, Analysis of vapor absorption system, Electrolux system, Comparison of absorption and vapor compression system.; Psychometrics: Properties of air-vapor mixtures, Psychometrics, Psychometric charts, Law of water vapor-air mixture - Enthalpy of moisture - simple heating and Humidification, Dehumidification - Mixture of air streams.; Requirements of comfort Air-conditioning : Oxygen supply, Heat Removal, Moisture removal, Air motion, Purity of Air, Thermodynamics of human body, Comfort and comfort chart, Effective temperature, Factors governing optimum effective temperature.; Air conditioning systems: Processes in Air conditioning, Summer Air conditioning, Winter Air conditioning and year round air conditioning, load calculations.

Essential Reading:

1. C. P. Arora, ***A Course in Refrigeration and Air-conditioning,*** Tata Mc. Graw-Hill
2. H. F. Stoecker, ***A Text Book of Refrigeration and Air-conditioning***, Tata Mc. Graw-Hill.

Supplementary Reading:

1. W. F. Stoecker, ***Refrigeration and Air Conditioning*** - TMH.

ME 355 AIRCRAFT AND ROCKET PROPULSION 3 credits [3-0-0]

Introduction, Rocket system and aerodynamics of rockets, Fundamentals of gas turbine engines, Illustration of working principles of gas turbine engine, Propulsion system and operating principle, Thermodynamics of propulsion system, Engine performance parameters, The ramjet cycle, Working principles of ideal ramjet cycle, The turbojet cycle, Working principles of turbojet cycle, Non-ideal turbojet cycle, Axial flow fans and compressors, Polytrophic efficiency of compression, Calculation of stage performance and overall performance, Working principles of turbofan cycle, Rocket performance, Introduction and working principles of multistage rocket, Solid propellant rockets, Liquid propellant rockets, Thrust control in liquid rockets Cooling in liquid rockets, Hybrid rockets, Limitations of hybrid rockets, Relative advantages of liquid rockets over solid rockets

Essential Reading:

1. G. C. Oates, ***Aerothermodynamics of Aircraft Engine Components***, AIAA Eduction Series, New York, 1985.
2. W. W. Bathie, ***Fundamentals of Gas Turbines***- John Wiley & Sons, 1984.
3. M. L. Mathur and R. P. Sharma, ***Gas Turbine Jet and Rocket Propulsion***, Standard Publishers and Distributors, Delhi, 1988.
4. P. G. Hill, ***Mechanics and Thermodynamics of Propulsion***- Addison Wesley, 1970.
5. S. M. Yahya, ***Fundamentals of Compressible Flow*** - John Wiley, New York, 1982.
6. A. K. Mohanty, ***Fluid Mechanics*** - Prentice Hall, New Delhi, 2003.

ME 356 TURBOMACHINERY 3 credits [3-0-0]

Ideal and actual velocity triangles, Slip and its estimation, Impulse and reaction type machines, Degree of reaction, Effect of outlet blade angle on blade shape, Model laws, Specific speed and shape number, Special features of hydro, steam and gas turbines, Performance characteristics of turbo-machines; Axial flow compressors: Flow through cascades, cascade terminology, flow separation, radial equilibrium theory, actuator disc theory, effect of tip clearance, secondary flow, performance characteristics, surging and stalling; Axial flow turbine: Vortex theory, blade design, cooling of turbine blades, performance characteristics, profile loss, secondary flow loss, annulus loss, tip clearance, limiting factors in turbine design; Applications: Hydel power plant, Steam power plant, Gas turbine power plant, Aircraft propulsion.

Essential Reading:

1. G. T. C. Sandy, ***Theory of Turbomachines***, McGraw Hill.

2. D. G. Shepherd, ***Principles of Turbomachinery***, MacMillan.
3. G. F. Wislicenus, ***Fluid Mechanics of Turbomachines***, Dovers.
4. S. M. Yahya, ***Turbines, Compressors and Fans***, TMH.

ME 357	GAS DYNAMICS	3 credits [3-0-0]

Energy equation for a flow process, Stagnation values, various regions of flow, critical velocity of sound. Crocco number, Effect of Mach number on compressibility, rate equations of momentum energy and entropy; Isentropic flow with variable area: Mach number variation, Stagnation and critical states, Area ratio as a function of Mach number, Impulse function, Mass flow rate, Flow through nozzles and diffusers, use of gas tables; Wave motion: Wave propagation in elastic solid medium, Propagation of sound waves, pressure field due to a moving source of disturbance, Mach angle; Flow with normal shock waves: Governing equation, variation of Mach number, Static Pressure, temperature and density etc. across the shock, Strength of a shock wave, Moving shock waves; Flow in constant area ducts with friction: The Fanno curves, Fanno flow equations and solutions, variation of flow properties, tables and charts for Fanno flow; Flow in constant area ducts with heat transfer: The Rayleigh lines, Fundamental equations, Rayleigh flow relations, Variation of flow properties, Maximum heat transfer, Tables and charts of Rayleigh flow; Jet propulsion: Thrust equation, maximum thrust relationship, Engine performance parameters, Ram Jet engine, ideal ram jet, ideal and actual turbojet engines; Rocket propulsion: Operating principle, thrust equation, specific impulse, jet velocity, thrust coefficient, characteristic velocity, impulse weight ratio.

Essential Reading:

1. S. M. Yahya, ***Fundamentals of Compressible Flow***, Wiley Eastern Ltd.
2. Lipman and Rosco, ***Gas Dynamics***, Mc Graw Hill

ME 370	HEAT TRANSFER AND REFRIGERATION LAB.	2 credits [0-0-3]

To find overall heat transfer coefficient of a double pipe heat exchanger; To develop a correlation for natural convection of air around a vertical cylinder; To study the boiling heat transfer phenomena and determination of CHF for pool boiling of water; Measurement of thermal conductivity of solid by gaurded hot plate method; To determine the efficiency of a pin-fin in natural and forced convection; To find the heat transfer coefficient in forced convection of air in a tube; COP and Tonnage capacity of room air-conditioner; Performance study of vapour compression refrigeration test rig; Determination of COP and tonnage capacity of ammonia ice plant; Performance study of absorption refrigeration test rig; Performane study on LN_2 Cryo-plant; Performane study on Pulse tube refrigerator

ME 372	FLUID MECHANICS & FLUID MACHINES LAB.	2 credits [0-0-3]

Verifications of momentum equation; Verifications of stokes apparatus; Calibration of Venturimeter; Verifications of Bernoulli's equation through a convergent and divergent passage; Study of Major losses in Pipes; Study of Minor losses in Pipes; Velocity distribution in a pipe flow; Velocity distribution in open channel flow; Variable and constant speed characteristics of Pelton turbine; Performance characteristics of Francis Turbine; Performance characteristics of Kaplan Turbine; Constant discharge and constant speed characteristics of centrifugal pump; Pressure characteristics of a centrifugal blower; Determination of air power, static and overall efficiency of a fan at constant speed; Pressure characteristics of axial flow compressor; Study of simple/compound impulse and reaction steam turbines; Thermal efficiency of steam turbine; Performance study of screw compressor.

ME 373	PRODUCTION ENGG. LAB.	2 credits [0-0-3]

Calibration of slip gauge using interference of light by Interference Method; Internal taper and bore measurement using two precision spheres; External taper measurement by sine center; Bulge test of thin Aluminum blank in to a dome by hydraulic pressure and study it's forming characteristics; Calibration of linear variable differential transformer (LVDT); Measurement of screw parameters by floating carriage machine; Measurement of tool angles of a single point cutting tool; Metrology of an external screw thread by "Tool maker's Microscope"; Experiment on machining in machining center (CNC); Condition monitoring in machining processes using acoustic emission; Experiments on Ultra Sonic Machining; Experiments on Electro Discharge Machining; Experiments and demonstration of Laser Machining; Experiments and demonstration of Electro Chemical Machining process; Experiments and demonstration of Abrasive Jet Machining; Programming on various CNC machine tools and use of CIM

ME 374	COMPUTATIONAL FLUID DYNAMICS LAB.	2 credits [0-0-3]

CFD analysis for fluid flow problem with heat transfer over a flat plate; CFD analysis for fluid flow problem with heat transfer through a circular tube; Design of a thermal system: Thermal Power Plant; Calculation of heating/cooling load for a conditioned space; Second law analysis for a heat exchanger; FDM application to high velocity flow with upwinding; FDM application to simplified Navier-Stokes equation; FEM applied to flow around a cylinder.

ME 375 IC ENGINES AND AUTOMOBILE ENGG. LAB. 2 credits [0-0-3]

Study of Two/Four stroke petrol/diesel engine; Determination of volumetric efficiency of reciprocating air-compressor; Valve timing diagram of four-stroke petrol/diesel engines; Load test on petrol Engine; Load test on diesel engine; Morse test on multi-cylinder petrol/diesel engine; Heat Balance study of petrol/diesel engine; Study of differential and transmission system of automobile; Study of 4-speed/5-speed gear box of automobile; Study of electric circuit and ignition system of automobile; Emission Analysis of I. C. Engines; Variable compression ratio test on I. C. Engines; CFR engines with pressure Vs Crank angle diagram – combustion process and emission control studies; Performance tests on multi-cylinder CI engines with bi-fuel operation & heat recovery system of exhaust gas.

ME 380 PRODUCTION ENGINEERING PROJECT 2 credits [0-0-3]

Design and drawing of single point cutting tool for turning operation; Design and drawing of Form tool for mass production of conventional profile generation; Design and drawing of Broach tool for industrial mass production; Design and drawing of metal forming Press tool used in blanking & punching; Design and drawing of Jig & Fixture for mass production in a product focused system; Design and drawing of Gauges used in shop floor dimensional checking; Process planning for manufacturing by mass; Process planning for manufacturing by order; Tool layout optimization for a capstan lathe/machining center; Design of forging die blocks for mass production; Design and draw of metal forming Press tool used in deep drawing; Computer Aided Design of forging/forming die/ cutting tool for optimal function; Conceptual Design of a machine tool with better ergonomics/ environment friendly/ low cost/ less maintenance/ less running cost/ high precision etc.

ME 381 MACHINE ELEMENT DESIGN PRACTICE – II 2 credits [0-0-3]

Problems for practice on theories of failure; Problems for practice on fatigue and failure; Design of clutches; Design of spur gears; Design of spiral and bevel gears; Design of crank, piston and cylinders; Design of connecting rods, crank shafts; Design of Journal bearings; Design of ball bearings, roller bearings; Design of valves of IC engines.

ME 410 ADVANCED MECHANICS OF SOLIDS 3 credits [3-0-0]

Elementary concept of Elasticity: Stresses in three dimensional bodies, Equations of equilibrium, Strain displacement relations, Stress strain relations, Compatibility equations, Boundary conditions. Plane stress, Governing differential equation, Airy stress function (Cartesian co-ordinates); Energy Methods: Castigliano's theorems, Maxwell's theorem of Reciprocal relations and Betti's Law, Principle of virtual work, Unit load and unit couple method; Thick Walled Cylinders: Thick cylinders subjected to internal and external fluid pressures, Compound cylinders, Shrink-fit; Unsymmetrical Bending: Properties of beam cross sections, Slope of neutral axis, Stresses and deflections in unsymmetrical bending; Shear Center of thin wall beam cross section; Curved Beams: Bending of beams of large initial curvature, Stress distribution in beams with rectangular, Circular and trapezoidal cross sections, Location of neutral axis, Stresses in crane hooks, Rings and chain links; Membrane stresses in shells, application to cylindrical, Spherical and conical shells; Plastic Analysis of Beams: Plastic Modulus, Shape factor, Plastic hinge, Application to beams, Determination of collapse loads; Advanced Topics in Strength of Materials: Repeated stresses in structural and machine components, Fatigue in metals, Endurance limit, Concept of stress concentration, Stress concentration factor and notch sensitivity; Photoelastic Stress Analysis: Two dimensional photoelastic method of stress analysis, Stress optic law, Plane polariscope, Light and dark fields in a polariscope, Isoclinic and isochromatic fringe patterns.

Essential Reading:

1. L. S. Srinath, ***Advanced Mechanics of Solids*** - TMH, New Delhi.
2. S. P. Timoshenko, D. Van Nostrand ***Strength of Materials***, Part I & II -.
3. J. W. Dally and W. F. Riely, ***Experimental Stress Analysis*** - Mc Graw-Hill.

Supplementary Reading:

1. A. P. Boresi, R. J. Schmidth and O. M. Sidebottom, ***Advanced Mechanics of Materials*** - John Wiley.
2. F. B. Seely and J. O. Smith, ***Advanced Mechanics of Materials*** - John Wiley.
3. Mobin, ***Experimental Stress Analysis,*** Khanna Publishers, 2003.

ME 411 VIBRATION AND NOISE ENGINEERING 3 credits [3-0-0]

Undamped Free Vibration: Systems with single degree of freedom, Equilibrium method, The energy method, Rayleigh's method, Stiffness of spring elements. Damped Free Vibrations: Viscous damping, laws of damping, logarithmic decrement. Forced Vibration with Harmonic Excitation: Steady state solution with viscous damping, Method of complex algebra, Reciprocating and rotating unbalance, Base excitation, Vibration isolation, Air springs, Energy dissipated by damping, Equivalent viscous damping, Structural damping, Sharpness of resonance, Vibration measuring instruments, Whirling of rotating shafts, Rigid shafts supported by flexible bearings. Two degree of freedom system: Vibration of undamped two degree of freedom system, coordinate coupling, vibration absorber. Multi-degree freedom system: Influence coefficients, generalized co-ordinates, matrix method, orthogonality principle, matrix iteration method. Vibration of Beams: Uniformly loaded, Carrying more than one concentrated load, Energy method, Dunkerley's method, Rayleigh's method. Torsional Vibration: Two rotor system, three rotor system, multi-rotor system, Geared system.

Essential Reading:

1. W. T. Thompson, ***Theory of Vibration with Application,*** CBS Publisher, 2002

ME 412	ADVANCED MACHINE DYNAMICS	3 credits [3-0-0]

Advanced Kinematics: Computer Aidedkinematics analysis of four link and slider crack mechanisms, coupler curves and their properties. Design of Mechanisms by relative pole and inversion method, Coordination of angular displacements of input and output links & position of coupler point; Gyroscope: Gyroscopic couple - Plane disc, Two bladed air screw, Analysis of the forces on bearings due to the forced precession of rotating disc mounted on shafts, Gyroscopic effects on a two wheel and a four wheel vehicle, Gyroscopic stabilization; Cams: Simple Harmonic, Constant - velocity and constant acceleration types, Displacement, Velocity and acceleration of follower, cams with specified contours; Governors: Centrifugal Governors-Watt & Porter Governors, Spring Loaded Governor, Hartnell Governor, sensitiveness, stability, Isochronism, hunting, governor effort & power, curves of controlling force, Effect of friction; Balancing: Balancing of revolving masses in one plane and different planes, Partial balance of single cylinder engine, Balancing of multi cylinder engine, V and radial engines, graphical and analytical methods, method of direct and reverse cranks, dynamic balancing machines.

Essential Reading:

1. S. S. Rattan, ***Theory of Machines***, MGH
2. R. K. Bansal, ***Theory of Machines***, Luxmi Publisher
3. D. R. Malhotra, ***Theory of Machines***, Satya Prakash

Supplementary Reading:

1. Rao & Dulchipati, ***Mechanism of M/C theory***, New Age
2. Ghosh & Mallick, ***Theory of Mechanism & Machines***, East West Press
3. AS Hall, ***Kinematics & Linkage Design***, PHI

ME 413	EXPERIMENTAL STRESS ANALYSIS	3 credits [3-0-0]

Photoelasticity: Light and Optics as Related to Photoelasticity Behavior of Light, Polarized Light, Plane Polarizers,, Wave Plates, Arrangement of Optical Elements in a Polariscopic, Constructional Details of Diffused Light and Lens - Type. Theory of Photoelasticity: The Stress Optic Law in Two Dimensions at Normal Incidence, Effects of a Stressed Model in a Plane Polariscope, Effects of a Plane Model in a Circular Polariscope with Dark and Light Field Arrangements. Analysis Techniques: Isochromatic Fringe Patterns, Isoclinic Fringe Patterns, Compensation Techniques, separation Techniques, Sealing Model to Prototype Stresses. Three Dimensional Photoelasticity: Locking in Model Deformation Slicing the Model and Interpretation of the Resulting Fringe Pattern, Effective Stresses. the Shear Difference Method in Three Dimensions.; Strain Measurement Methods: Basic Characteristics of a Strain Gauge, Types of Shell Gauge, Moire Method of Strain Analysis, Grid Method of Strain Analysis. Electrical Resistance Strain Gauge: Factors Influencing Strain sensitivity in Metallic Alloys, Gauge Construction Temperature Compensation, Factors-Influencing Gauge Section Gauge Sensitivity and Gauge Factor, Correction for transverse Strain Effects, Semiconductor Strain Gauges. Rosette Analysis - three element rectangular Rosette. the Delta Rosettee, the Four Element. The Delta Rosette, The Stress Gauge, Strain Circuits, Potensiometer Circuits, The Wheatstone Bridge. Brittle Coating Method: Coating Stresses, Failure Theories Brittle Coating Crack Patterns Produced by Direct Loading Brittle-Coating Crack Patterns Produced by refrigeration Techniques, Brittle Coating Crack, Pattern Produced by Releasing the Load, Double Crack Pattern, Crack Detection, Load-Time Relation and Its influence on the threshold Strain Effects of a Biaxial stress Field.

Essential Reading:

1. J. W. Dally and W. F. Riley, ***Experimental Stress Analysis*** - 2nd Ed. MGH.
2. Mubin, ***Experimental Stress Analysis***, Khanna, 2003.

Supplementary Reading:

1. Dureli. ***An Introduction to Experimental Stress and Strain Analysis.***
2. Srinath et. al. ***An Introduction to Experimental Stress Analysis*** - MGH.

ME 414	MECHATRONICS	3 credits [3-0-0]

Introduction to Mechantronics- Systems-Measurement Systems-Control Systems-Mechatronics Approach; Sensors And Transducers: Introduction-Performance Terminology-Displacement, Position and Proximity-Velocity and Motion-Fluid, Pressure-Temperature Sensors-Light Sensors-Selection of Sensors- Processing; Signal Conditioning: signal conditioning, operational amplifier, filtering, multiplexer, data accusation; Microprocessor: Introduction-Architecture-Pin Configuration-Instruction set Programming of Microprocessors using instructions-Interfacing input and output devices Interfacing D/A converters and A/D converters-Applications-Temperature control-Stepper motor control-Traffic light controller; Programmable Logic Controllers: Introduction-Basic structure-Input/Output Processing-Programming-Mnemonics-Timers, Internal relays and counters-Data handling Analog Input/Output-Selection of a PLC; Design And Mechatronics: Stages in Designing mechatronic systems – Traditional and Mechatronic design -Possible design solutions-Case studies of mechatronic systems – Pick and place robot - automatic car park system -engine management system.

Essential Reading:

1. Bolton, ***Measurements***, Addison Wesley.
2. HMT, ***Mechatronics***, TMH

Supplementary Reading:

1. Histand and Aliatore, ***Introduction to Mechatronics and Measurement system***, MGH
2. A. K. Stiher, ***Design with Microprocessor for Mechanical Engineers***, MGH

ME 415	FUNDAMENTALS OF TRIBOLOGY	3 credits [3-0-0]

Introduction to tribology and its historical background. Factors influencing Tribological phenomena. Engineering surfaces - Surface characterization, Computation of surface parameters. Surface measurement techniques. Apparent and real area of contact. Contact of engineering surfaces- Hertzian and non-hertzian contact. Contact pressure and deformation in non-conformal contacts. Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, various laws and theory of friction. Stick-slip friction behavior, frictional heating and temperature rise. Friction measurement techniques. Wear and wear types.

Mechanisms of wear - Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., Wear of metals and non-metals. Wear models - asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage. Wear in various mechanical components, wear controlling techniques. Introduction to lubrication. Lubrication regimes. Introduction to micro and nano tribology.

Essential Reading:

1. G Bayer, ***Mechanical wear prediction and prevention***- Marcel Dekkar. Inc., New York
2. P. Sahoo. ***Industrial Tribology***, Tata Mc Graw Hill

ME 416	ROBOTICS	3 credits [3-0-0]

Introduction, Automation and Robotics, brief history, Social and economic aspects, Advantages overview of robots and future application; Classification & structure of robotic system: Classification, Configuration, wrist, end effectors, Links, Joints, Drive system; Control System: Basic control system concepts, model, transformation and block diagrams, controllers ON & OFF, transient response; Robot Kinematics: Direct & inverse kinematics, rotation matrix, composite rotation matrix, homogenous transformations, links, joints D-H representation, Geometrical approach of direct & reverse kinematics; Robot Arm dynamics: Joint velocities, KE, PE & motion equation of manipulating trajectory planning, joint interpolated trajectory; Robot Programming: Languages, Graphics, Storing & operating, Task programs; Sensors: State and external state sensors, tactile and non-tactile sensors, force – torque sensors, Image processing & analysis, Computer vision.

Essential Reading:

1. Groover, ***Industrial Robot***, PHI.
2. Y. Korem, ***Robotics***, Mc Graw-Hill.

ME 417 CONTROL SYSTEM ENGINEERING 3 credits [3-0-0]

Closed loop and open loop system, design principles of control systems, Laplace transforms method, transfer functions, block diagrams, deriving transfer functions of physical systems, signal flow graphs, proportional, derivation and integral controllers, impulse response functions; First order systems, second order systems, higher order systems, Routh's stability criterion, static and dynamic error coefficients, introduction to system optimization; Root locus plots, root locus analysis of control systems; Logarithmic, polar and log magnitude versus phase plots, Nyquist stability criterion, stability analysis, closed loop frequency response lag, lead compensations; Nonlinear control systems, describing function analysis of nonlinear control systems; Introduction to discrete time systems, state space representation of systems, optional control systems and adaptive control systems.

Essential Reading:

1. K. Ogata, ***Modern Control Engineering***, PHI.

ME 418 MATERIAL HANDLING 2 credits [3-0-0]

Introduction: Development of Material Handling Technology, Design objectives; Classification and characteristics of materials, Types of industrial transport, classification and working principles of materials handling devices; Cranes: Structural and mechanical design of electrical overhead traveling cranes; Conveyors: Design of belt, Apron, Screw, Roller, Vibrating and pneumatic conveyors; Elevators: Design of bucket, Arm and swing tray elevators; Steel mill cranes: Working principles and operations of various types of steel mill cranes such as stripper, charger, ladle and soaking pit cranes.

Essential Reading:

1. A. Spivakovsky and V. Dyackov, ***Conveyors and related equipments***, MIR Publishers.
2. N. Rudenko, ***Materials handling equipment***, MIR Publishers.
3. M. P. Alexandrov, ***Materials handling equipment***, MIR Publishers.

ME 430 INDUSTRIAL MANAGEMENT 3 credits [3-0-0]

Management Concept, Principles and Functions of Management, Evaluation of Scientific Management; Forms of Industrial Organization Structure, Authority, Responsibility, and Span of Control, Factors affecting Span of Control, delegation of authority; Types of industrial Ownership, Formation of companies, Authorized Capital, Shares, Debentures, Bonds and Sources of Finance, Introduction to balance sheet and profit and loss statement; Engineering Economics – Break Even Analysis, Interest Calculation, Depreciation, Choosing of alternatives; Materials management – Functions, Objectives, Purchasing Procedure, Inventory Management, EOQ, ELS, Discount and Shortage Models, Inventory Classification Models viz., ABC, VED analysis etc, Introduction to MRP, JIT, OPT and ERP; Marketing Management: Selling concept v/s Marketing Concept, Marketing Mix, Marketing function; Time and Motion study – Procedures, Process Chart, Multiple Activity chart, SIMO Chart, Standard Time, Normal Time, Rating factor, Work sampling; Personnel Management: Functions of Personnel Management, wages and incentive Plans, Job Evaluation, Merit Rating; Productivity – Concepts, Total and Fractional Productivity Indices, Types of Wastes, Waste Elimination Techniques, Productivity Cycle; Quality management – Quality costs, Definition of T Q M, Leadership, Motivation, Seven tools of Quality, Participatory Approaches, Quality Function Deployment, Value Analysis, International Quality Systems, ISO Registration Procedure and Implementation strategies, Intellectual property Rights, ISO 9000 and 14000.

Essential Reading:

1. O. P. Khanna, ***Industrial Engineering and Management***, Khanna publishers, New Delhi.
2. Dr. K. C. Arora, ***TQM and ISO 14000***, S. K. Kataria & Sons, New Delhi.

ME 431 DECISION MODELING 3 credits [3-0-0]

Linear Programming – Formulation and Solution of LPP, Duality, Sensitivity Analysis, Dual Simplex Method, Transportation and Assignment Problem, Goal Programming, Simple Case Studies, Introduction to OR Software package; Production Planning & Control – Short range and Long range Planning, Production Planning, Master Production Schedule, Capacity Planning, Aggregate Planning, GANT Chart Forecasting, Time series, Causal and Predictive Methods, Forecasting using neural network (back propagation algorithm), Scheduling and Sequencing, Flow shop and Job Shop scheduling, Flow shop scheduling using Johnson's rule, Branch and Bound Technique and Genetic Algorithm; Plant Layout – Types of layout, Design of Functional Layout using CRAFT, ALB Problems, Solution of ALB Problem using heuristics (Largest Candidate Rule, Ranked Positional Weight, Combination of heuristics, and COMSOAL) and Simulated Annealing, Group Technology, Classification and Coding Systems, Solution of GT problems using heuristics viz. ROC-I, ROC-II and MODROC and neural networks (Adaptive Resonance Theory); Plant Location

– Introduction to subjective and objective factors, Brown Gibson Model, Multiple Locations, Application of AHP in plant Location; Project Management –. Project Network, Critical path, PERT & CPM, Crashing and Resource Leveling; Simulation – Random Variables, Random Number Generation, Simulation of simple Queuing Models, Validation and Data collection; Decision Environment – Decision making under Certainty, Risk and Uncertainty, Decision Tree, Game Theory; Maintenance management - Preventive, Predictive and Corrective maintenance, Determination of Optimum Schedule for Maintenance, Replacement analysis.

Essential Reading:

1. H. A. Taha, ***Operation Research: An Introduction***, 8th Edn. PHI, New Delhi.
2. L. J. Krajewski, L. P. Ritzman, M. K. Malhotra, ***Operations Management***, 6th Edn. PHI, New Delhi.

ME 432 NON-CONVENTIONAL MACHINING PROCESSES 3 credits [3-0-0]

Modern Machining Processes: Electro Discharge Machining (EDM), Processes mechanism of material removal, parameters effects EDM & application, Electrical Discharge Grinding(EDG), Traveling Wire EDM, Electro-chemical Machining (ECM), Processes, Mechanism of material removal, Tool design, Parameters affecting ECM, Applications, Electro-chemical Honing(ECH), Electrochemical Deburring (ECD), Electrochemical Grinding(ECG), Electrochemical Discharge Grinding, Chemical Machining, Ultrasonic Machining, Cutting Tool System Design, Mechanism of cutting, Parameters affects USM applications, Abrasive Jet Machining, Variables of AJM, Nozzle Design, Laser Beam Machining, Thermal and Non-thermal analysis, and applications, Electron – Beam Machining and its mechanism, Applications, Plasma arc machining, Equipments, Arc transfer mechanism, Metallurgical efforts, Safety precautions and applications, Plasma are surfacing and plasma Arc Springing, Iron Beam machining and water Jet Machining.

Essential Reading:

1. HMT - ***Production Technology*** - TMH, 1980.
2. G. F. Benedict, ***Non Traditional Manufacturing Processes***, Marcel Dekker, 1987.

Supplementary Reading:

1. Bhattacharya, ***New Technology*** - I.e.(India), 1973.
2. Pandey, ***Modern Machining process*** - TMH, 1980.

ME 433 ADVANCED MANUFACTURING SYSTEMS 3 credits [3-0-0]

Definition and broad characteristics of Flexible Manufacturing Cells, Systems, Islands and Flexible transfer lines - Place of flexible manufacturing systems in CIM - The FMS relational: Economics and technological justification for FMS - Design and Planning: the role of associated technologies such as GT, JIT and simulation - Installation, Operation and evaluation - Scheduling problems - FMS hardware CNC machines tools, robots, AGVs, ASRs, Inspection and Cleaning stations - Control aspects of FMS-DNC of machine tools, cutting tools, robots, quality control and inventories - Personnel and infrastructural aspects - Flexible machining cells and islands - Flexible assembly Systems; structure, control and applications - FMS in action: Understanding Flexibility, Types of Flexibility in FMS, Flexible and Dynamic Manufacturing Systems, IT facilitated flexibility, integration and automation, Role of Integrated and automated material handling systems, Typical FMS operation, IT based Tools: Computer simulation and AI for FMS, Group technology, Decision Support Systems, Design, Planning, Scheduling and Control Issues in FMS, Real time control strategies, Various FMS configurations, Computer configurations, FMS as mini-CIM, Benefits and Justification for FMS, Role of Information Technology, Overview of Multi model and mixed model flexible lines, Typical case studies. Future prospects.

Essential Reading:

1. M. P. Groove, ***Automation, Production systems & Computer Integrated Manufacturing***, PHI.
2. P. Radhakrishna and V. Raju, ***CAD, CAM & CIM***, New Age, International Publisher.

ME 434 COMPUTER GRAPHICS FOR CAD/CAM 3 credits [3-0-0]

Fundamental of CAD: The design process, Application of computers for design, Creating the manufacturing data base, The design work station, Graphics terminal, Operator input devices, Plotters and other output devices, The CPU, Secondary storage. Graphics output devices, Rasterization, scan conversion. Raster scans Graphics: Algorithms for rasterization of straight lines and circles. Display Generation Techniques: Real time scan conversion, Run-length encoding, Cell organization, Frame buffer memory. Curves and Surfaces: Splines, parametric curves, Bezier and B-spline curves and surfaces, ruled surfaces and surfaces of revolution. Solids and their properties: Surfaces and curves in solids, Intrinsic and global properties, Characteristic tests and Intersections. Solid Modeling: Data structures and Boolean operations. Computer Graphics Display Interface: Modeling transformations, Viewing transformations, Projections, Clipping, Hidden line/surface elimination, shading and light sources, Double buffering, Hardware graphics engines. Computer-aided drafting, Parametric drafting, Design visualization, Integration with NC machines and manufacturing. Scientific Visualization: Animation, physical principles. Graphics Standards: 2D and 3D standards and graphics portability Introduction to Product data standards and data structures database integration for CAD/CAM.

Essential Reading:

1. Groover and Zimmer, ***CAD / CAM***, Prentice Hall of India.
2. D. Hearn, M. P. Balles, ***Computer Graphics***, Pearson Ed. Publisher
3. D. D. Voisinet, ***Introduction of Computer Aided Drafting*** by McGraw Hill Co.
4. S. Harring Ton, ***Computer Graphic***, Mc Graw Hill Publisher.

Supplementary Reading:

1. D. F Rogers, ***Procedural elements for computer graphics***, TMH Publisher.
2. Rogers, D. F. and Adams, A., ***Mathematical Elements for Computer Graphics***, McGraw-Hill Inc., NY, 1989.
3. I. D. Faux and M. J. Pratt, ***Computational Geometry for Design and Manufacture***, John Wiley and Sons, NY, 1979.
4. M. E. Mortenson, ***Geometric Modelling***, John Wiley and Sons, NY, 1991.

ME 435 CONCURRENT ENGINEERING 3 credits [3-0-0]

Product life cycle, quality products, evaporative markets, globalization and Concurrent engineering. Review of concurrent engineering techniques like DFM (design for manufacture). DFA (design for assembly), QFD (quality function deployment), RP (rapid prototyping), TD (total design) for integrating these technologies. Product information systems and their architecture. Information environment for suppliers, management, testing & inspection design engineering, purchasing, process control, manufacturing, support plans, operators, quality control, servicing and maintenance. Product information modeling. Integration of information models and end users applications. Computer aided simultaneous engineering systems. Integrated concurrent design and product development. Constraint networks. created by capacity expansion and professional resource expansion. Case studies, DYNAMO, STELLA and SD based management games.

Essential Reading:

1. C. G. Miller, ***Concurrent Engineering Design: Integrating the Best Practices for Process Improvement***, Landon.
2. D. D. Bedworth, M. R. Henderson and P. M. Wolfe, ***Computer Integrated Design and Manufacturing***, 1991. McGraw Hill.

ME 436 ENTREPRENEURSHIP 3 credits [3-0-0]

Enterprise Launching and Resourcing: Environmental Analysis: Entrepreneurial process and enterprise building, environmental scanning & analysis, Institutions and their role, procedures for launching small scale industries, incentives and finances available to SSI units and new entrepreneurs. How to identify and select good business opportunity; Project formulation: Feasibility; industry and firm level feasibility, study of formats of applications of financial institutions, determining project size, investment magnitude and forms of organization, estimation of cost, project scheduling, financial analysis, plant layout; Enterprise Management: Basic management concepts: Functions of management, planning, organizing, directing, controlling, coordinating. Introduction to computers and management information systems, business communication; Personnel management: Work motivation, labor relations, wage administration, incentives etc; Production management: Production, planning and control routing. Scheduling, dispatching, expediting and evaluation. production scheduling technique, quality control inspection. Standards and specifications – ISI; Financial Management including costing & Accounting practices: Tools of financial analysis, volume, profit analysis, sensitivity analysis, management of working capital, financing of working capital requirements, financial accounting, cost accounting, risk taking and insurance; Marketing management: Role of marketing in small industry and business. Importance of consumer's point of view, consumer behavior, buying habits, marketing, packing, pricing policies and practices, product mix-segmentation of marketing, sales control, appraisal of sales performance, management of receivables, Advertising and sales promotion, Introduction to import/export procedures; Problem solving and innovation; Industrial and business laws: Laws governing business operation, laws governing taxation, laws governing personnel.

Essential Reading:

1. B. B. Chadda, ***Basics of Business***, Executive publishers, New Delhi.
2. V. Desai, ***Problems and Prospects of Small Scale Industries***, Himalaya Pub. House, Bombay.

ME 437	WELDING TECHNOLOGY	3 credits [3-0-0]

Introduction, types of welding, conventional and non conventional welding, fusion welding processes, heat flow in welding, chemical reactions in welding, fluid flow and metal evaporation in welding, residual stresses, distortion and fatigue, basic solidification concepts, weld metal solidification, : - grain structure, microstructure within grains, post solidification phase transformation, weld metal chemical in homogeneities, weld metal solidification cracking, the partially melted zone: formation of the partially melted zone, difficulties associated with the partially melted zone, the heat affected zone: work-hardened materials, precipitation –hardening materials: aluminum, nickel based alloys, transformation –hardening materials: carbon and alloy steels, corrosion-resistant materials: stainless steels.

Nomenclature of welded joint, types of welded joint, design consideration of weldment, failure analysis of the welded joint, testing of weldment, process control parameters of welding, properties of desired weldment: bead geometry, HAZ, mechanical-metallurgical characteristics of the weld, weld chemistry, parametric optimization of welding, different types of optimization techniques; advantages and limitations, case study.

Essential Reading:

1. Little, ***Welding & Welding Technology***, McGraw Hill Publication

Supplementary Reading:

1. Dr. O. P. Khanna, ***A Textbook of Welding Technology***, Dhanpat Rai Publications (P) Ltd. 2000

ME 450	COMPUTATIONAL FLUID DYNAMICS & HEAT TRANSFER	3 credits [3-0-0]

Introduction: Basic tools of CFD, Numerical vs. experimental tools. Mathematical Behavior of PDEs: Parabolic, Hyperbolic and Elliptic PDEs. Methodology of CFDHT: Discrete representation of flow and heat transfer domain: Grid generation, Governing equations and boundary conditions based on FVM/FDM, Solution of resulting set of linear algebraic equations, Graphical representation and analysis of qualitative results, Error analysis in discretization using FVM/FDM. Solution of 1-D/2-D steady/unsteady: Diffusion problems, Convection problems, Convection-diffusion problems, source term linearization. Explicit and Implicit Approach: Explicit and implicit formulation of unsteady problems, Stability analysis. Solution of Navier-Stokes Equations for Incompressible Flows: Staggered and collocated grid system, SIMPLE and SIMPLER algorithms. Special Topics in CFDHT: Numerical Methodology for Complex Geometry, Multi-block structured grid system, Solution of phase change problems.

Essential Reading:

1. S V. Patankar, ***Numerical Heat Transfer and Fluid Flow*** by Taylor and Francis.

Supplementary Reading:

1. H. K. Versteeg and W. Malalasekra, ***Introduction to Computational Fluid Dynamics***: The Finite Volume Method by Prentice Hall (2nd Edition)
2. Jr D. A. Anderson, ***Computational Fluid Mechanics and Heat Transfer***, McGraw-Hill Education.
3. M. N. Ozisik, ***Finite Difference Method***, CRC (1st Edition).

ME 451	POWER PLANT ENGINEERING	3 credits [3-0-0]

Vapor Power Cycles: Rankine cycle, Comparison of Rankine and Carnot vapor cycles, Regenerative cycles, Ideal working fluid for vapor power cycles, Binary vapor cycle, Thermodynamics of couples cycles, Process heat and by-product power.; Steam Generators: Classification of boilers, Description of Cochran, Lanchashire and Babcock-Wilcox boilers, Boiler mounting and accessories, High pressure boilers, Lamont, Benson and Velox boilers.; Nozzle: Introduction, Types of nozzles, Flow of steam through nozzles, Momentum equation, Entropy change with friction, Effect of friction, Calculation of nozzle area, Mass flow, Critical pressure, Stagnation enthalpy and pressure, Effect of friction on critical pressure ratio, Super-saturated flow in nozzles, Effect of variation of back pressure.; Steam Turbines: (a) Principles of operation of steam turbine, Types of steam turbine, Compounding of steam turbine. (b) Impulse Turbine: Velocity diagram, Effect of blade friction, Forces on Blades, Work done, Diagram efficiency, Stage efficiency, Gross stage efficiency, Choice of blade angles, Blade heights etc. (c) Impulse Reaction Turbine: Velocity diagram, Degree of reaction, Parson's turbine, Blade sections, Internal losses in steam turbine, State point locus and reheat factor.; Condensers: Jet and surface type - Dalton's law of partial pressure and its application to condenser, Air leakage, Extraction pump and air-pump, Cooling water requirement, Vacuum efficiency.; Nuclear Power Plants: Release of nuclear energy, Criticality of reactors, Thermal reactors, nuclear fuels, Moderator, Reflector, Coolant and control of reactors, BWR, PWR and gas cooled reactors.

Essential Reading:

1. P. K. Nag, ***Power Plant Engineering***, TMH Publication
2. El-Wakil, ***Power Plant Technology,*** Mc Graw Hill Publication

ME 453 ENERGY CONSERVATION & WASTE HEAT RECOVERY 3 credits [3-0-0]

Pattern of energy use, potential for energy conservation, optimum use of energy resources, total energy approach. Coupled cycles, combined plants and cogeneration systems; Need for energy storage, thermal electrical, magnetic and chemical energy storage systems; Utilization of industrial waste heat; gas-to-liquid and liquid-to-liquid heat recovery systems; Recuperation and regenerators heat pipes; waster heat boilers; fluidized bed heat recovery; shell and tube heat exchangers; Prime mover exhausts; incineration plants; heat pump systems; thermoelectric devices; Utilization of low grade reject heat from power plants; Thermal insulation; energy economics.

Essential Reading:

1. R. G. Stick and A. Thumann, ***Principles of Waste Heat Recovery***, PHI, 1986.

ME 455 NUCLEAR POWER GENERATION AND SAFETY 3 credits [3-0-0]

Descriptions of nuclear power plants and operations, Thermodynamics of nuclear power, Nuclear power cycles, Fluid systems analysis and introduction to two-phase flow, Heat generation in nuclear reactors, heat conduction in fuel matrixes, Heat transfer and fluid flow phenomena in rod bundles, Heat transfer with phase change, Quenching and rewetting phenomena in rod bundles, Hydrodynamics of countercurrent two-phase flow, Nuclear reactor accidents, Loss of coolant accident and emergency core cooling system, Principles and methods used in safety evaluation of complex engineered systems, Safety characteristics of LWR and BWR, Safety culture, Safety improvements in nuclear reactors, Waste management, Indian nuclear power programme.

Essential Reading:

1. M. M. EI. Wakil, ***Nuclear Power Engineering***, McGraw Hill Book Company, New York, 1987.
2. S. Glasstone and A. Setonske, ***Nuclear Reactors Engineering*** - CBS Publishers and Distributors, 1992.
3. T. J. Connoly, ***Fundamentals of Nuclear Energy***- John Wiley, 1978.
4. J. H. Rust, ***Nuclear Power Plant Engineering***, Haralson Publishing Company.

ME 457 CRYOGENIC ENGINEERING 3 credits [3-0-0]

Definition of cryogenics, applications – industrial gases, LNG, space propulsions, superconducting devices; properties of Fluids and Materials at low temperature, Refrigeration and Liquefaction cycles – Linde, Claude, Stirling, GM, and their derivatives, storage of cryogenic liquids, design of storage vessels. Vacuum Technology – definition, production and measurement of vacuum, multilayer insulation and application. Superconductivity and Superconducting devices.

Essential Reading:

1. K. D. Timmerhaus and T. M. Flynn, ***Cryogenic Process Engineering***, Plenum Press, 1989.
2. A. R. Jha, ***Cryogenic Technology and Application***, Butterworth-Heinemann, 2006.

ME 470 DESIGN ENGINEERING LABORATORY 2 credits [0-0-3]

Critical speed of shafts; Measurement of damping; Study of cam and follower kinematics; Experiment on vibration measurement set-up; Experiment on gyroscope; Study of dynamic balancing machine; Balancing of a rotating shaft; Experiment on epicyclic gear trains; Calibration of photoelestic model; Isochromatic fringe pattern for a specimen under bending; Calibration of strain gauge; Stress measurement using strain rosette; Experiment on journal bearing test rig; Experiment on abrasion tester; Erosion tester; Ferrograpgh analysis.

ME 480 THERMAL ENGINEERING DESIGN PROJECT 2 credits [0-0-3]

Mathematical modeling and curve fitting of linear algebraic systems; Numerical model for a Thermal system and System simulation; Calculation of interest and worth of money as a function of time; Lagrange multipliers and Optimization of constrained and unconstrained problems; Search methods: Single-variable problem and Multivariable constrained optimization; Design of thermal systems: Geometric, linear, and dynamic programming

ME 481 MECHANICAL SYSTEM DESIGN PROJECT 2 credits [0-0-3]

Introduction and salient features of EOT crane design; Design of trolley structure; Design of main girder; Design of side truss; Design horizontal truss; Design of members; Design of gantry girder and column; Design of mechanical components, rope, pulley, drum; Design of crane hooks, brakes, drives etc.

ME 483	INDUSTRIAL ENGINEERING PROJECT	2 credits [0-0-3]

Generation and Testing of Random numbers: Solution of Queuing problem; Design of Network system and find its optimal solution; Formulation and solution of practical industrial problems using LP; Solution of Transportation and Assignment problem; Conceptual Design of a product focused system for high volume rate; Design of Functional Layout using numerical technique; Conceptual Design of a job shop for optimal man & machine use; Optimal cell formation for batch production; Brain storming session to reach an optimal decision point; Design and determination of Optimal Schedule for Maintenance for a medium plant; Application of advanced forecasting techniques for sales; Acquaintance with advanced Flow shop and Job Shop scheduling techniques

DEPARTMENT OF METALLURGICAL & MATERIALS ENGINEERING

DETAILED SYLLABI OF COURSES

MM 201	Metallurgical Thermodynamics and Kinetics	3-1-0	4
MM 211	Science and Technology of Materials	3-1-0	4
MM 212	Casting and Solidification of Materials	3-1-0	4
MM 215	Physics of Materials	3-1-0	4
MM 220	Unit Process of Extraction	3-1-0	4
MM 227	Fuel Technology	3-0-0	3
MM 256	Transport Phenomena	3-0-0	3
MM 257	Non – Metallic Materials	3-0-0	3
MM 258	Experimental Technique	3-0-0	3
MM 268	Ceramic and Powder Metallurgy	3-0-0	3
MM 270	Electro Metallurgy & Corrosion Laboratory	0-0-3	2
MM 271	Mineral Dressing Laboratory	0-0-3	2
MM 272	Characterization of Material Laboratory	0-0-3	2
MM 273	Polymer Laboratory	0-0-3	2
MM 311	Phase Transformation	3-1-0	4
MM 314	Heat Treatment of Metallic Materials	3-1-0	4
MM 317	Materials Technology	3-0-0	4
MM 318	Principles and Practice of Heat Treatment	3-0-0	3
MM 321	Ironmaking	3-1-0	4
MM 324	Steelmaking	3-1-0	4
MM 325	Iron and Steel Making	3-0-0	3
MM 326	Non Ferrous Extractions	3-1-0	4
MM 331	Deformation Theory of Metals	3-1-0	4
MM 336	Mechanical Working of Metallic Materials	3-1-0	4
MM 345	Nuclear Metallurgy	3-0-0	3
MM 352	Material Characterization Techniques	3-1-0	4
MM 356	Pollution in Metallurgical Industries and its Control	3-0-0	3
MM 357	Corrosion and Degradation of Materials and their Prevention	3-1-0	4
MM 358	Experimental Techniques in Material Engineering	3-0-0	3
MM 359	Engineering Polymers and Composites	3-0-0	3
MM 370	Fuel Testing Lab.	0-0-3	2
MM 371	Thermodynamics & Kinetics Lab.	0-0-3	2
MM 372	Thermal Analysis Laboratory	0-0-3	2
MM 373	Mechanical Testing Lab.	0-0-3	2
MM 374	Structure Property Correlation project	0-0-3	2
MM 375	Metallography & Heat Treatment Lab.	0-0-3	2
MM 376	Computational Technique in Materials Engg. Lab.	0-0-3	2
MM 391	Special Topic in Metallurgical & Mat. Engineering - I		3/4
MM 392	Special Topic in Metallurgical & Mat. Engineering - II		3/4

MM 393	Special Laboratory in Metallurgical & Mat. Engineering - I	0-0-3	2
MM 394	Special Laboratory in Metallurgical & Mat. Engineering - II	0-0-3	2
MM 395	Engineering Product Development Project - I	0-0-6	4
MM 396	Engineering Product Development Project - II	0-0-6	4
MM 408	Energy, Environment & Recycling	3-0-0	3
MM 416	Complex Ferrous & Non Ferrous Alloys	3-1-0	3
MM 426	Secondary Steelmaking	3-0-0	3
MM 427	Sponge Iron Technology	3-1-0	4
MM 428	Advances in Steelmaking	3-1-0	4
MM 431	Mechanical Behaviour of Materials	3-1-0	4
MM 435	Fracture Mechanics and Fatigue of Metals	3-1-0	4
MM 442	Advanced Materials	3-0-0	3
MM 446	Composite Materials	3-1-0	4
MM 448	Advanced Engineering Materials	3-0-0	3
MM 449	Nanostructured Materials	3-0-0	3
MM 468	Joining of Metals	3-1-0	4
MM 471	Composite Materials Lab.	3-0-0	2
MM 472	Modeling of Materials Processes	0-0-3	2
MM 473	Design & Calculation Lab.	0-0-3	2
MM 491	Research Project – I	0-0-6	4
MM 492	Research Project – II	0-0-9	6
MM 493	Seminar & Technical Writing – I	0-0-3	2
MM 494	Seminar & Technical Writing – II	0-0-3	2
MM 495	Short Term Industrial / Research Experience	0-0-0	2
MM 496	Comprehensive Viva- Voce	0-0-0	2

For B. Tech Courses (3 or 4 level) please refer to the B. Tech Curriculum and Syllabi, for M. Tech Courses (6 level) please refer to M. Tech Curriculum and Syllabi.

MM 201 METALLURGICAL THERMODYNAMICS AND KINETICS 4 Credits [3-1-0]

Basic concepts of systems; State and Path functions; Internal energy and Thermodynamics Processes; First law of thermodynamics and its application for various metallurgical processes; Heat capacity; Enthalpy changes; Second law of thermodynamics and entropy; Entropy changes for various processes; Free energy and its significance; Free energy change as a function of temperature; Gibbs – Helmholtz equation; Concepts of standard state, fugacity, activity and equilibrium constant; Van't Hoff equation; Criteria for thermodynamic equilibrium; Maxwell's equations; Third law of thermodynamics; Ellingham diagram (ΔG^0 – T diagram) and its significance in Metallurgical Engineering; Thermodynamics of solutions; Gibbs – Duhem equation; Raoult's law; Ideal, non-ideal and regular solutions and their thermodynamic properties; Henry's law and alternative standard states; Excess quantities; Activities in multi-component systems. Basic concepts of reaction rates; Arrhenius equation in reaction kinetics; Mechanism of reaction and rate controlling steps; Activated complex and its thermodynamic & kinetics aspects; Kinetics of heterogeneous reactions; Fick's laws of diffusion and their applications; Diffusion in interstitial and substitutional solid solutions; Diffusion coefficients; Mass transfer at solid-fluid interface; Mass transfer coefficient and its application to dimensional analysis; Concept of concentration boundary layer; Kinetic steps involved in the reduction of iron ore and roasting of sulphides.

Essential Reading:

1. L. S. Darken and R. W. Gurry, ***Physical Chemistry of Metals***, McGraw Hill, N. Y.
2. D. R. Gaskell, ***Introduction to Metallurgical Thermodynamics***, McGraw Hill, N. Y.

3. R. A. Swalin, ***Thermodynamics of Solids***, John Wiley, N. Y.
4. G. S. Upadhyay and R. K. Dubey, ***Problems in Metallurgical Thermodynamics and Kinetics,*** Pergamon, N. Y.

Supplementary Reading:

1. R. H. Tupkary, ***Introduction to Metallurgical Thermodynamics***, T. U. Publishers, Nagpur.
2. A. Ghosh, ***Text book of Materials and Metallurgical Thermodynamics***, Prentice Hall of India, New Delhi.
3. T. Rosenquist, ***Principles of Extractive Metallurgy***, McGraw Hill, N. Y.
4. G. H. Geiger & D. R. Poirer, ***Transport Phenomena in Process Metallurgy***, Addison Wesley, N. Y.
5. J. Szekely & N. J. Themelis, ***Rate Phenomena in Process Metallurgy***, John Wiley, N. Y.
6. S. Glasstone, K. J. Laidler & H. Eyring, ***Theory of Rate Processes***, Mc. Graw Hill, N. Y.
7. A. K. Mohanty, ***Rate Processes in Extractive Metallurgy***, Prentice Hall of India.

MM 211 SCIENCE & TECHNOLOGY OF MATERIALS 4 Credits [3-1-0]

Crystal Structure**:** Space lattices and Bravais lattices**,** Miller Indices of planes and directions, slip planes and slip directions. Bonding in Solids**:** Ionic, Covalent, and Metallic bonding, Substitutional and interstitial solid solution, Hume Rothery Rules, Intermetallic compounds, Normal valency compounds, Electron compounds, Interstitial compounds. Imperfections: Point defects, Vacancies, Interstialcies, Dislocations; Edge & Screw dislocations; Burgers vector. Binary Phase Diagrams: Isomorphous, Eutectic, Peritectic, Eutectoid, Monotectic and Syntectic systems, Phase rule and Lever rule. Iron-Cementite Equilibrium diagrams and its applications, Plain carbon and alloy steel, Industrial applications of steels. Diffusion: Fick's First and Second law of diffusion, Atomic model of diffusion, Grain boundary, surface and thermal diffusion, Kirkendall Effect, Interstitial diffusion. Nucleation: Homogeneous and Heterogeneous nucleation, Kinetics of nucleation, Growth and overall transformation kinetics.

Essential Reading:

1. V. Raghavan, ***Materials Science and Engineering***, Prentice-Hall of India Private Limited (2003).
2. W. F. Smith, Mc Graw Hill, ***Principles of Materials Science and Engineering***, New York (1994).

Supplementary Readings:

1. R. E Reid Hill, ***Physical Metallurgy Principles***, PWS-Kent Publishing (2004).
2. Vijendra Singh, ***Physical Metallurgy***, Standard Publisher (2008).
3. W. D. Callister, ***Materials Science & Engineering, An Introduction***, John Wiley & Sons (2007).
4. L. H. Van Vlack, Addison Wisley, ***Elements of Materials Science and Engineering***, New York (1985).

MM 212 CASTING AND SOLIDIFICATION OF MATERIALS 4 Credits [3-1-0]

Introduction**:** Casting as a process of Manufacturing. Moulding Processes, Equipments and Mechanization**:** Different types of Moulds, Moulding Materials and Moulding processes, Pattern and other mould making equipments, forces acting on moulds, Mould factors in metal flow, Moulding factors in casting design. Different types of binders and their uses in mould and core-makings. Melting of Metals and Alloys for casting: Brief mention of various melting units, melting and post melting treatments, melting practices as adopted for a few metals and alloys such as CI, Al, Cu, steels, cast irons. Solidification of Metals and Alloys: Nucleation, Growth, Role of alloy constitution, Thermal conditions and inherent nucleation and growth conditions in the liquid melt, Significance and practical control of cast structure

Principles of Gating and Risering: Feeding characteristics of alloys, Types of Gates and Risers, Time of solidification and Chowrinov rule, Wlodawer system for feeder head calculations, gating ratio, concept of directionality in solidification, Yield of casting and prescription for its augmentation. Special casting Methods: Investment casting, Die casting, Centrifugal casting, Full mould casting, Vacuum sealed casting. Casting Defects: A detailed analysis of casting defects. Their causes and prescription of remedial measures.

Essential Reading:

1. P. R. Beeley, ***Foundry Technology***, Newnes-Buttterworths, 2001.
2. P. D. Webster, ***Fundamentals of Foundry Technology***, Portwillis press, Red hill, 1980.

Supplementary Reading:

1. P. C. Mukherjee, ***Fundamentals of Metal casting Technology***, Oxford IBH, 1980.
2. R. W. Hein, C. R. Loper and P. C. Rosenthal, ***Principles of Metal casting***, Mc Graw Hill, 1976.

MM 215 PHYSICS OF MATERIALS 4 Credits [3-1-0]

Crystallography: Crystalline and amorphous structures, Elements of Crystal Symmetry, Symmetry elements and axes, two, three, four and six fold Symmetry, Review of atomic bonding. Order-Disorder Transformation: Ordering, Degrees of long range and short range ordering, Anti phase Domain, Super lattice, Elements of Super lattice Theories, Properties and Applications. Electron Theory of Materials: Heisenberg's uncertainty Principle, Schrodinger's equation. Free Electron Theory, Zone Theory, Density of States, Fermi Energy Level, Application of Zone Theory to Alloy Phases; Conductors and Insulators, Semiconductors, P & N – Type Semiconductors. Magnetic Properties: Dia, Para and Ferro-magnetism, Domain Theory of Ferromagnetism Antiferromagnetism and Ferrites, Hysteris loop, Soft Magnetic Materials, Hard Magnetic Materials, Super Conductivity, BCS Theory, Type-I & Type-II Super Conductors. Elements of X-ray Diffraction: X-ray, Bragg's Law, Laue, Rotating Crystal and Powder Methods, Structure Determination with the help of X-ray.

Essential Reading:

1. W. Hume Rothery and B. R. Coles – Atomic Theory for Students of Metallurgy. The Institute of Metals (London) (1988).
2. R. E. Reid – Hill, ***Physical Metallurgy Principles***, East – West Press Pvt. Ltd., (New Delhi), (2004).

Supplementary Reading:

1. S. L. Kakani and A. Kakani, ***Material Science,*** New Age International Publishes Ltd., (New Delhi) (2004).
2. R. A. Higgins, ***Engineering Metallurgy,*** Standard Publishes Distributors (Delhi) (1998).
3. M. S. Vijaya, G. Rangarajan, ***Materials Science,*** Tata McGraw Hill Publishing Company Limited (New Delhi) (2004).
4. V. Raghavan, ***Material Science and Engineering***, Princep Hall (New Delhi) (2003).
5. C. S. Barrett and T. B. Massalski, ***Structure of Metals,*** Euresia Publishing House (Pvt.) Ltd., (New Delhi) (1968).

MM 220 UNIT PROCESS OF EXTRACTION 4 Credits [3-1-0]

Introduction: Role of Unit Processes in Metal Extraction; Ore preparation: Principles of Comminution, Crushing and Grinding, Sizing of comminuted particles, Drying, Calcination, Roasting, Sintering; Role of Ellingham diagrams in Extraction of metals; Pyrometallurgical Processes: Reduction and smelting using Blast furnace and Electric arc furnace, Flash smelting, Converting, Principles of metallothermic reduction, Refining processes such as Fire refining, Liquation, Zone Refining, Distillation and Vacuum Refining; Hydrometallurgical Processes: Leaching, Various types of Leaching such as Pressure leaching and Bacterial leaching, leaching methods such as In-situ, Heap, and Percolation leaching, Mechanical and Pneumatic vats, Solution purification methods such as Chemical, Ion exchange and Solvent extraction, Cementation; Electrometallurgical Processes: Faraday's laws, Review of properties of aqueous electrolytes, Ionic mobilities, Transport number and Conductivity in electrolytes, Debye-Huckle limiting law. Mean activity coefficient of ions in electrolytes, Electrode potential, Polarization, Gas and Metal over voltage, E. M. F. of cells, Elementary theory of Electro deposition, Electro winning and Electro refining; Brief idea of metal extraction processes in the Indian context; Calculations of material and heat balances pertaining to some important metal extraction processes.

Essential Reading:

1. C. Bodsworth, ***Extraction and Refining of Metals***, CRC Press, 1994.
2. A. Ghose and H. S. Ray, ***Principles of Extractive Metallurgy***, Wiley Eastern, 1991.

Supplementary Reading:

1. H. S. Ray, R. Sridhar, K. P. Abraham, ***Extraction of Non-ferrous Metals***, Affiliated East-West Press Pvt. Ltd., New Delhi-1985.
2. T. Rosenquist, ***Principles of Extractive Metallurgy***, McGraw hill, 1974.
3. R. D. Pehike, ***Unit Processes of Extractive Metallurgy***, American Elsevier, N. Y., 1968.

MM 227 FUEL TECHNOLOGY 3 Credits [3-0-0]

Introduction of fossil fuels and their world-wide reserves; Primary and secondary fuels, Coking and non-coking coals. Characterization of coal properties (caking and swelling indices, calorific value, proximate and ultimate analyses, etc.); Coal carbonization and effects of different parameters; Properties of coke, char and graphite. Selection of coal for sponge iron making and thermal power plants; Fuel combustion and the effects of different factors; Combustion calculations. Alternative sources of energy (viz. ferro-coke, formed coke, charcoal, solar, wind, tidal, etc.) and their suitability for metallurgical and power industries; Renewable and non-renewable sources of energy; Activated carbon and its uses; Modern trends in the utilization and conservation of fossil fuels. Properties and uses of gaseous fuels like coke oven gas, blast furnace gas, basic oxygen furnace gas, producer gas, etc.; Petroleum coke and its utilization in metallurgy. Solid energy wastes and their possible industrial applications; World-wide approach in the utilization of energy wastes; Energy crises and its possible solution.

Essential Reading:

1. Her Majesty's, ***The Efficient use of fuels,*** Published stationary office, 423, Oxford Street, London W. I.
2. Marion L. Smith and Karl W. Stinson, ***Fuels and Combustion*** McGraw-Hill Book Company, Inc. New York.

Supplementary Reading:

1. S. B. Pandya, ***Conventional Energy Technology – Fuels and Chemical Energy,*** Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
2. Samir Sarkar, ***Fuels and Combustion***, Orient Longman Ltd., Mumbai.
3. S. P. Sharma and C. Mohan, ***Fuels and Combustion***, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

MM 256 TRANSPORT PHENOMENA 3 Credits [3-0-0]

Fluid Flow**:** Classification of fluids, ideal & real, Newtonian & Non-Newtonian, Newton's law of viscosity. Types of fluid flow – streamline & turbulent, continuity equation for incompressible and compressible fluid and its application. Concept of velocity bounds layer.; Bernoulli's equation and its application for flow measurement by venturimeter, orifice meter, pilot tube and rotameter. Dimensional analysis by Rayleigh's method of indices and Buckingham's π theorem. Example of analysis of pressure gradient, mass transfer co-efficient & convective heat transfer co-efficient, concept of similarly and dimensionless criteria. Dimensionless groups & their significance. Pressure drop & friction factor in various configurations, flow in packed bed & fluidized bed. Free and partially restricted jets, high velocity fluid jets. Mass Transfer: Law of diffusion and their application, concept of mass transfer co-efficient & concentration boundary layer, Interfacial mass transfer, overall mass balance. Heat Transfer: Internal & External modes of heat transfer, steady state heat conduction in monolayer and composite flat walls & cylinders. Unsteady state heat conduction, thin & massive body heating & cooling. Finite difference method in solving unsteady state heat conduction. Natural and forced convection, concept of heat transfer co-efficient, thermal boundary layers, some examples of connective co-relations. Law of radiation – Steffan-Boltzmann's law, Kirchoff's law & Lambarth's law, Black & grey body concepts, view factor, Radiation from flames & gases. Radiation between simple surfaces with & without absorbing gas media. Radiation shields. Overall Heat transfer co-efficient.

Essential Reading:

1. R. B. Bird, W. E. Stewart and E. N. Lightfoot, ***Transport Phenomena***, Wiley, 1994.
2. G. H. Geiger and D. R. Poirier, ***Transport Phenomena in Materials Processing***, Addison Wesley, Mass, 1994.

Supplementary Reading:

1. J. R. Welty, R. E. Wilson and C. E. Wicks, ***Fundamentals of Momentum Heat and Mass Transfer,*** Wiley, 1976.
2. R. I. L. Guthrie, ***Engineering in Process Metallurgy,*** Oxford Science, 1992.

MM 257 NON – METALLIC MATERIALS 3 Credits [3-0-0]

Classification of materials, Bonding, Crystal structure, Imperfections in solids, Relationship between structure, property and processing, Basic principles of materials selection. Polymers: Applications, Structure of polymers, Mechanism of deformation and strengthening of polymers, Crystallization and Glass transition phenomena in polymers, Conduction in organic materials, Doping effects and copolymerization, Superconducting inorganic polymers (SN), Polymers in metallurgical applications. Bio-degradable polymers. Ceramics: Applications, Structure and properties of ceramics, Types of ceramics, Hi-tech ceramics, Bioactive and bioresorbable ceramics, Principles of ceramic processing. Composites: Classification of composite materials, Dispersion strengthened, Particle-reinforced and fiber-reinforced composites, Properties of matrix and reinforcement materials, Micromechanics and principles of strengthening, Elastic properties, stress-strain relations, Polymer matrix composites, Ceramic matrix composites, Processing and properties, Applications. Biodegradable composites. Special materials: Carbon fullerene and nanotubes, Core-shell structures, Organic-inorganic hybrids, Intercalation compounds, Mesoporous materials, Nanocomposites.

Essential Reading:

1. W. D. Callister, ***Materials Science and Engineering: An Introduction,*** Willey Publishers, 2007.
2. D. R. Askeland and P. P. Phule, ***The science and Engineering of Materials***, Thomson Publishers, 2003.

Supplementary Reading:

1. Chapman and Hall, ***Composite Materials: Engineering and Science,*** 1994.
2. P. Vencizini, Elsevier, ***High Tech Ceramics***, 1987.

MM 258 CERAMIC AND POWDER METALLURGY 3 Credits [3-0-0]

Introduction of ceramics, Common ceramics crystal structures: silicates, clay, minerals, graphite and carbides. Classification and applications of ceramics materials. Raw materials preparation, Different structural ceramics: their properties and applications. Mechanical behavior of different structural ceramics-brittleness of ceramics, Concept of fracture toughness and different toughness measurement techniques, Elastic modulus, Strength measurement, Weibull theory. Processing and properties of ceramics composites, Powder preparation: Powder flow, Compressibility and porosity measurements, Powder forming, Consolidation and different powder processing routes, Behavior of powder during compaction: Die compaction. Different modern powder compaction methods: Hot isostatic pressing, Spark plasma sintering, and Microwave sintering. Sintering of powders and evaluation of sintered products. Sintering theories, Solid and liquid phase sintering, Characterization of powders: composition and their structure, Particle size and shape determination. Applications of sintered products: Thermal, friction, High temperature, Corrosion, Bearing, Magnetic and electrical applications.

Essential Reading:

1. W. D. Kingery, H. K. Bowen, D. R. Uhlmann, ***Introduction to Ceramics,*** Wiley Publishers, 1986.
2. Randall German, John Wiley & Sons, ***Powder Metallurgy,*** 2006.

Supplementary Reading:

1. M. N. Rahaman, Marcel Dekker, ***Ceramic processing & Sintering***, 1995.

MM 270	ELECTRO METALLURGY & CORROSION LAB.	2 Credits [0- 0- 3]

Electro winning of Cu from acidified $CuSO_4$ solution; Electro winning of Zn from $SnSO_4$ solution; Electro deposition of Cu on mild steel electrode from acid bath; Electro deposition of Cu on mild steel electrode from an alkaline bath; Deposition of Nickel on Cu plate by electro plating and thickness determination of deposit by BNF Jet test; Determination of throwing power and throwing efficiency of alkaline Cu plating solution; Monitoring of corrosion rate of mild steel; Anodisation of given Aluminium rods; Electro deposition of Brass on mild steel plate from cyanide bath.

MM 271	MINERAL DRESSING LAB.	2 Credits [0- 0- 3]

To determine the average size of particles by Sieve Analysis; To study the Jaw crusher and to determine the actual capacity and reduction ratio; To study a hammer mill and to determine its actual capacity and reduction ratio; To study the effect of ball load on grinding operation in a ball mill; Verification of Rittinger's Law of crushing in a Jaw crusher; To study the vibrating screen and determination of its effectiveness; Study of magnetic separator and determination of its efficiency; To study a simple jig and to determine its efficiency; Study of Wilfley table and to find out its efficiency; Study of flow diagram for extraction of copper; Study of flow diagram for beneficiation of coal.

MM 272	CHARACTERIZATION OF MATERIALS LAB	2 Credits [0- 0- 3]

Preparation and examination of metallography specimens; Primary calibration of thermocouple and measurement of melting point of a metal; Theory and practice of thermal analysis: Scanning calorimeter; Dilatometer; Thermo gravitometer. High temperature microscopic study of: Ceramic material; Metallic material; Topological and elemental analysis of metallic sample by SEM; Theory and practice of XRD technique.

MM 273	POLYMER LABORATORY	2 Credits [0- 0- 3]

Synthesis of a polymer; Determination of "Melt–flow–index" of the polymer samples supplied in the Laboratory; Fabrication of polymer test – specimen using "injection moulding" techniques out of the polymer samples supplied in the laboratory; Fabrication of polymer test specimen using "press moulding" techniques out of Bakelite powder supplied; Tensile testing of the polymer test specimen fabricated in the laboratory using Instron-1195; Effect of temperature/time on curing behavior; Study of viscosity behaviour of polymer; Determination of glass transition, crystallization and melting temperatures.

MM 311	PHASE TRANSFORMATIONS	4 Credits [3-1-0]

Thermodynamics and Kinetics of solid state Phase transformation, Atomic models of Diffusion, Allotropy of Iron and Fe-C Phase diagram, Functions of alloying elements, Importance of Austenite Grain size; Formation of Austenite, TTT and CCT Diagrams, Homogeneous and Heterogeneous nucleations, Strain energy effects; Overall Transformation Kinetics, Empirical equations, Transformation kinetics for Interface-controlled and Diffusion-controlled growth; Pearlitic, Bainitic and Martensitic Transformations (Mechanisms, Kinetics and Morphologies). Pearlitic transformation, Factors influencing pearlitic transformation, Mechanism of transformation, Nucleation and growth, Orientation relationship; Bainitic transformation: Mechanism of transformation, Nucleation and growth, Orientation relationships, Surface relief, Classical and non-classical morphology, Effect of alloying elements; Martensitic transformation: Characteristics of transformation, Thermodynamics and kinetics, Nucleation and growth, Morphology, Crystallography, Stabilization;

Strengthening mechanisms, Recovery, Recrystallization and Grain growth, Annihilation of point imperfections, Mechanism of nucleation and driving force for growth; Massive and Spinodal Decomposition, Mechanism and Kinetics of precipitation of age-hardenable alloys.

Essential Reading:

1. D. A. Porter and K E Easterling, ***Phase Transformations in Metals and Alloys***, CRC Press.
2. V. Raghavan, ***Solid State Phase Transformations***, PHI.

Supplementary Reading:

1. J. W. Christian, ***The Theory of Transformations in Metals and Alloys***, Pergamon Press.
2. J. E. Hilliard, ***Phase Transformations***, ASM.
3. S. H. Avner***, Introduction to Physical Metallurgy***, Tata McGraw-Hill.
4. R. E. Reed-Hill, ***Physical Metallurgy Principles***, East-West Press.
5. A. K. Jena and M. C. Chaturvedi, ***Phase Transformation in Materials***, Prentice Hall

MM 314	HEAT TREATMENTS OF METALLIC MATERIALS	4 Credits [3-1-0]

Objective and variables of heat treatments, Limitation of Fe-Fe_3C Phase Diagram, Formation of Austenite, TTT and CCT Diagram, Types of TTT Diagram. Application of TTT Diagrams (Martempering, Austempering and Patenting). Annealing (Full, Homogenising, Spheroidisation and Stress-relieving annealing), Normalising, Comparison of Annealing and Normalising, Hardening and Tempering of plain and alloy steels, Hardening (Objective, Austenitizing temperature and Internal stresses), Quenching Mediums and Methods, Retained austenite and Defects in hardening, Tempering of steels, Aims and stages of tempering, Effects of Carbon and alloying elements, Tempering of alloy steels and Multiple tempering, Embrittlement during tempering, Hardenability and its determination, Factors affecting hardenability. Case and Surface hardening: Carburising, Nitriding and Carbonitriding, Induction and Laser Hardening. Heat treatments of general engineering steels: Spring, Bearing steels, Tool steels, HSLA steel and Maraging steels, Dual phase steels and Stainless steels, Heat Treatments of Al-alloys, Cu-alloys and Ti-alloys. Age-Hardening: Types and sequence of precipitates, Mechanism and kinetics of precipitation. Heat-treatment defects and their rectification.

Essential Reading:

1. B. Zakharov, ***Heat Treatment of Metals***, CBS Publishers.
2. ***Principles of Heat Treatment of Steels***, ASM.

Supplementary Reading:

1. C R Brooks, ***Principles of the Heat Treatment of Plain Carbon and Low Alloy Steels***, ASM International.
2. R Kumar, ***Physical Metallurgy of Iron and steels***, Asia Publishing House.
3. G. Krauss, ***Steels: Processing, Structure and Performance***, ASM International.
4. K E Thelning, ***Steel and Its Heat Treatment,*** Butterworth.
5. W C Leslie, ***The Physical Metallurgy of Steels***, MeGraw-Hill International.

MM 317	MATERIALS TECHNOLOGY	3 Credits [3-0-0]

Metallic Materials: Concept of phase diagram crystallography and microstructure, Steels, Different types of Steel, Iron-Iron Carbide phase diagram, TTT and CCT diagrams. Heat-Treatment of steels: Annealing, Normalizing, Hardening and Tempering of steels, Plain carbon steels and their applications. Alloy steels: High speed steels, stainless steels, HSLA; Non Ferrous alloys: Al alloys, Cu alloys, applications of these alloys, Magnesium alloys, Titanium alloys and Zirconium alloys. Electrical and Magnetic properties of materials: Band Structure, Conductors, Insulators, semiconductors, superconductors, p-n junction and application of these properties. Engineering polymers and composites: Thermoplastics, Thermosetting polymers, processing of composites, Hybrid composites. Ceramics: Different ceramics available, Properties of ceramics, Crystal structure, Overview of Ceramic Applications, Processing of ceramics, Densification and sintering, Mechanical properties and characterization. Mechanical Characterization: Tension test, Fatigue test, Creep test, Hardness, Impact Tests, Fracture of materials, Modes of fracture. Non Destructive Testing: Ultrasonic Radiography, X-ray diffraction, Crystal Structure, Bragg's law, Liquid penetrant testing, Ultrasonic testing, Electromagnetic testing, Acoustic emission testing, Magnetic resonance imaging and NMR spectroscopy.

Essential Reading:

1. Van Vlack L H, ***Elements of Material Science and Engineering***, ISBN: 8131706001 ISBN-13: 9788131706008, Addison Wesley, 6th edition, 1967.
2. W. F. Smith, ***Principles of Materials Science and Engineering (McGraw Hill Series in Materials Science and Engineering),*** McGraw-Hill College; 3rd edition (1995) ISBN-10: 0070592411. ISBN-13: 978-0070592414
3. William D. Jr. Callister, Wiley, ***Materials Science and Engineering: An Introduction***, 7th edition (2006) ISBN-10: 0471736961

ISBN-13: 978-0471736967

Supplementary Reading:

1. Vernon John, ***Introduction to Engineering Materials,*** ISBN-10: 0333124650 ISBN-13: 9780333124659, Macmillan, 1972-06
2. James P. Schaffer, Ashok Saxena, Thomas H. Sanders, Jr. Stephen D. Antolovich, Steven B. Warner, McGraw, ***Science and Design of Engineering Materials***, -Hill Publishing Co.; 2nd edition (2000) ISBN-10: 0071131485 ISBN-13: 978-0071131483

MM 318	PRINCIPLE AND PRACTICE OF HEAT-TREATMENTS	3 Credits [3-0-0]

Objective and variables involved in heat treatments, Thermodynamics and Kinetics of phase transformation, Diffusion, Allotropy of Iron and Fe-C Phase diagram, Functions of alloying elements Limitation of Fe-C diagram. Formation of Austenite, TTT and CCT Diagrams. Pearlitic, Bainitic and Martensitic transformations; Heat treatment furnaces and furnace atmosphere. Annealing (Full, Homogenising, Spheroidization and Stress-relieving annealing), Normalising, Comparison of Annealing and Normalising, Hardening (Objective, Austenitizing temperature and Internal stresses), Quenching mediums and Methods, Retained austenite and Defects in Hardening. Tempering of steels, Aims and stages of tempering, Effects of Carbon and alloying elements, Tempering of alloy steels and Multiple tempering; Thermo-mechanical Treatment of steels: Principles and Practices, Ausforming and Isoforming; Heat treatments of general engineering steels: Spring, Bearing steels, Tool steels, HSLA steel, Maraging steels and Dual phase steels; Heat treatment defects and their rectification; Advances of heat treatment technology.

Essential Reading:

1. V. Singh, ***Heat Treatment of Metals***, Standard Publishers.
2. B. Zakharov, ***Heat Treatment of Metals***, CBS Publishers.

Supplementary Reading:

1. S H Avner, ***Introduction to Physical Metallurgy***, Tata McGraw-Hill.
2. R E reed-Hill, ***Physical Metallurgy Principles***, East-West Press.
3. I Novikov, ***Theory of Heat Treatment of Metals***,, MIR
4. W D Callister, ***Materials Science and Engineering***, Jr., Wiley India.
5. R E Smallman, ***Modern Physical Metallurgy***, Butterworth.

MM 321	IRONMAKING	4 Credits [3-1-0]

Raw materials and their properties: Iron ore, Limestone, Agglomerates and Coke. Preparation of ores: sintering and palletizing, blast furnace burdening and distribution, testing of raw materials for blast furnace. Design: Blast furnace profile, stove and gas cleaning units; instrumentation, refractory used in blast furnace and stove. Reactions: Fe-C-O, Fe-O-H phase equilibria, Reactions in stack, bosh and hearth; formation of primary slag, bosh slag and hearth slag. Slag composition and its control, Metal-slag reactions, Control of hot metal composition. Process Control: Factors affecting fuel consumption and productivity, Recent developments in Blast furnace operations like, Bell-less top charging system, High top pressure, Humidified & Oxygen enriched blast and Auxiliary fuel injection through tuyers.

Irregularities in blast furnace operation and their remedies. Alternative routes of iron making: Introduction, Processes of Sponge Iron production; SL/RN, MIDREX, HyL processes. Smelting Reduction Processes; COREX, ROMELT, Hismelt.

Essential Reading:

1. A. K. Biswas, ***Principles of Blast Furnace Iron Making***, SBA publication, Calcutta, 1999

Supplementary Reading:

1. A. Ghosh and A. Chatterjee: ***Ironmaking and Steelmaking Theory and Practice***, Prentice-Hall of India Private Limited, 2008
2. G. R. Bashforth, ***The Manufacture of Iron and Steel, Vol. I***, Chapman, London, 1962.
3. D. H. Wakelin (ed.): ***The Making, Shaping and Treating of Steel (Ironmaking Volume)***, The AISE Steel Foundation, 2004.

MM 324	STEELMAKING	4 Credits [3-1-0]

Introduction: Principles of steel making reactions, Viz. Decarburisation, dephosphorisation, desulphurisation, silicon and managanese reaction. Slag Theories: Molecular and Ionic theories; Interpretation of the above reactions in terms of ionic theory of slag. LD Process: Design of converter & lance, Quality of raw materials charged, Operation of the converter and control of bath and slag composition, Chemical reactions involved, Temperature and residual bath oxygen control, Use of oxygen sensor, Some characteristics of L. D. blow Viz. Emulsion formation, Slopping, Maneuvering lance height for dephosphorisation and decarbunisation. Catch Carbon technique, Recovery of waste heat, OBM/Q-BOP, Process, Concept and operation of the process, Mixed/Combined blowing Processes, Oxygen top blowing with inert gas purging at bottom, Oxygen top blowing with inert and oxidizing gases at bottom, Oxygen top and bottom blowing. Steel making scenario in India. Open Hearth Furnace: Its modification into Twin Hearth, Operational principle, Advantages. Electric Arc Furnace: Advantages; Charging, Melting and refining practices for plain carbon and alloy steels, Use of DRI in arc furnace and its effect on performance, UHP electric arc furnace with D. C. supply, Single graphite electrode, Oxygen lancing, Oxyfuel burner, Water cooled panel and computer control. Duplex processes of stainless steel making using VOD, AOD & CLU. Induction Furnace: Advantages, principle of induction melting, Its use in steel industry. Deoxidation of liquid steel: Requirements of deoxidisers, deoxidation practice, Stoke's law, Use of complex deoxidisers, Inclusions and their influence on quality of steel, Killed, Semi-killed and Rimming steel. Secondary refining of steel: Objectives, Principle of degassing, Different industrial processes such as DH, RH, VAD, SD. LF, and ESR, Limitations and specific applications. Continuous Casting of Steel: Advantages, types of machines, Mould lubrication and reciprocation, Developments in technology with respect to productivity, quality and energy conservation, Near-net-shape casting, Strip casting.

Essential Reading:

1. R. J. Fruehan (ed.), ***The Making, Shaping and Treating of Steel (Steel Making Volume),*** The AISE Steel Foundation, 2004.

Supplementary Reading:

1. Ghosh and A. Chatterjee, ***Ironmaking and Steelmaking Theory and Practice,*** Prentice-Hall of India Private Limited, 2008
2. R. G. Ward, ***Physical Chemistry of iron & steel making,*** ELBS and Edward Arnold, 1962.
3. F. P. Edneral, ***Electrometallurgy of Steel and Ferro-Alloys***, Vol. 1 Mir Publishers, 1979.

MM 325	IRONMAKING AND STEELMAKING	3 Credits [3-0-0]

Introduction, Blast Furnace Route for Iron Making; The Blast Furnace and its accessories, The burden and its preparation, Physical – Thermal and Chemical process in a Blast Furnace, Blast Furnace slag and its control, Control of hot metal composition, Blast Furnace plant and accessories, Modern trends in Blast Furnace practice, Control of irregularities in the blast furnace, Performance of Blast Furnace over the years. Alternative Methods: Need for alternative Methods, Sponge Iron production by using solid and gaseous reductants, Smelting Reduction Processes. Modern Steel Making: Different routes of steelmaking; Oxygen Steelmaking; Top and Bottom blown converter processes, Hybrid processes. Electric Steel making; Electric Arc furnaces, Induction furnaces. Secondary Steelmaking. Casting of liquid steel: Ingot Casting of Steel, Continuous Casting of Steel. Iron and Steel Scenario in India in the last decade.

Essential Reading:

1. Ahindra Ghosh and Amit Chatterjee: ***Ironmaking and Steelmaking Theory and Practice,*** Prentice-Hall of India Private Limited, 2008

Supplementary Reading:

1. Anil K. Biswas: ***Principles of Blast Furnace Iron making***, SBA Publication, 1999
2. David H. Wakelin (ed.): ***The Making, Shaping and Treating of Steel (Iron making Volume),*** The AISE Steel Foundation, 2004.
3. Richard J. Fruehan (ed.): ***The Making, Shaping and Treating of Steel (Steel making Volume),*** The AISE Steel Foundation, 2004.

MM 326	NON–FERROUS METAL EXTRACTION	4 Credits [3-1-0]

General principles of extraction of metals from oxides and sulphides; Mineral resources of non – ferrous metals in India; their production, consumption and demand; Future of non – ferrous metal industries in India; Kinetics of leaching of ores and the effects of operation variables. Aluminium: Bayer's process and factors affecting its operation; Hall – Heroult process: principle & practices, use of electrodes, anode effect; Refining of Aluminium; Alternative methods of Alumina and Aluminium production. Copper: Roasting of sulphides; Matte smelting; Converting; Refining; By – products recovery; Recent developments; Continues copper production processes, hydrometallurgy of copper. Zinc: Pyrometallurgy of zinc; principles and practices of roasting, sintering and smelting; Hydrometallurgy of zinc.; Lead: Roasting and agglomeration of galena concentrate; Blast furnace smelting; Refining of lead bullion. Uranium: Processes for the digestion of Uranium ores; Purification of crude salts; Production of reactor grade UO_2. Titanium: Methods for upgrading ilmenite; Chlorination of titania; Kroll & Hunter processes; Consolidation and refining. Other Metals: Simplified flow sheets and relevant chemical principles of extraction of Ni, Mg, Au, Be, etc.

Essential Readings:

1. K Grjotheim & B J Welch: ***Aluminium Smelter Technology***, Aluminium – Verlag, 2nd Edn. 1988.
2. A K Biswas & W G Devenport: ***Extractive Metallurgy of Copper***, Pergamon, 4th Edn. 2002.
3. W H Dennis, ***Metallurgy of Non – Ferrous Metals***, Pitman, London, 1954.
4. J N Anderson & P Queneau, ***Pyrometallurgical Processes in Non – Ferrous Metallurgy***, Gorden & Breach, New York, 1967.
5. N Sevryukov, ***Non – Ferrous Metallurgy***, Trans. By I V Savin, Mir Publishers, Moscow, 1975.
6. J L Bray, ***Non – Ferrous Production Metallurgy***, John Wiley, New York.
7. R D Pehlke, ***Unit Processes of Extraction Metallurgy***, Elsevier, Amsterdam, 1982.

MM 331	DEFORMATION THEORY OF METALS	4 Credits [3-1-0]

Elastic Behaviour: Concept of elasticity in three dimensions, Generalised Hook's Law, Plane stress and plane strain state, Strain energy, Stress intensity factor, Concept of finite element method. Theory of Plasticity: Flow curve; Yield criteria, Plastic stress strain relationship. Dislocation Theory: Line defects, Deformation by slip, Theoretical shear strength, Critical resolved shear stress, Burger's vector and dislocation loop, Edge, Screw, Mixed and Partial dislocations, Dislocation reactions, Dislocations in ***fcc*** and ***bcc*** crystals, Cross slip and climb of dislocations, Interaction of dislocations, Energy of dislocations, Forces on dislocations, Dislocation sources and multiplication of dislocations. Dislocation pile-ups and Bauschinger's effect, Strain hardening in single crystals and polycrystals, Yield point phenomenon, Strain aging, Dynamic strain aging, Strengthening mechanisms. Deformation Twinning: Classification, Slip vs. twinning, Stress for twinning.

Essential Reading:

1. G. E. Dieter, ***Mechanical Metallurgy***, McGraw Hill Publication, 1988.
2. D. Hull and DC Bacon, ***Introduction to Dislocation***, Elsevier Butterworth – Heinemann, Pub., 4th Ed. (2001).

Supplementary Reading:

1. Wole Soboyejo, ***Mechanical Properties of Engineering Materials***, Marcel Dekker Publication, 2003.
2. R. W. Hertzberg, ***Deformation and Fracture Mechanics of Engineering Materials***, John Wiley & Sons Publication, 1995.
3. R. E. Reed–Hill, ***Physical Metallurgy Principals***, Litton Education Publication, 2004

MM 336	MECHANICAL WORKING OF METALLIC MATERIALS	4 Credits [3-1-0]

Fundamentals of Metal Working**:** Classification of forming processes; Temperature in Metal– working, Hot working, Cold working and Warm working of metals, Heating of metals and alloys for hot working, Friction in Metal working, Lubrication, concept of yield criteria. Rolling of Metals**:** Classification of Rolled products, Types of rolling mills, Terminology used in rolling; Forces and Geometrical relationships in rolling, Rolling variables, Theories of rolling, Rolling Torque and HP calculations. Roll-pass Design: Fundamentals of Roll-pass-design; Mill type, Layout and rolling practice adopted for some common products such as Slabs, Blooms, Billets, Plates, Sheets etc. Rolling defects and their control. Forging of Metals**:** Forging principles, types of forging and equipments needed; calculation of forging load under sticking and slipping friction conditions. Forging defects and their control. Manufacture of rail wheels and tyres. Extrusion**:** Types, Principles and Equipments. Variables in extrusion, deformations in extrusion, calculation of extrusion pressure under plane strain conditions; extrusion defects; production of tubes and seamless pipes. Wire Drawing**:** Drawing of Rods, Wires and Tubes, calculation of drawing load; drawing defects. Sheet Metal Forming**:** Forming methods such as bending, stretch forming, shearing and blanking, deep drawing, and redrawing. Defects in formed products. Special forming methods such as explosive forming (elementary ideas excluding mathematical treatment).

Essential Reading:

1. G. E. Dieter, ***Mechanical Metallurgy,*** Mc Graw Hill-1988
2. ***Roll pass Design,*** the united steel companies Ltd., U. K. -1960

Supplementary Reading:

1. G. W. Rowe, ***Principles of Industrial Metal Workinging processes,*** Crane Russak, 1977.
2. Amitabh Ghosh, Asok Kumar Mallick, ***Manufacturing sciences,*** East-west press private ltd; latest reprint-1991.

MM 345	NUCLEAR METALLURGY	3 Credits [3-0-0]

Nuclear Structure: Structure of nucleus, binding energy, fission reaction, neutron cross sections, moderation of neutrons, multiplication factor, fusion reaction. Reactors and Materials: Classification of nuclear reactors, materials for nuclear reactors, fuels, moderators, control rods, coolant, reflectors and structural materials. Fabrication of fuel and cladding materials. Radiation Effects: Effect of radiation on reactor materials, Radiation hazards, safety and shielding, disposal of radioactive wastes. Production of Nuclear Materials: Atomic minerals, their occurrence in India, General methods of their processing. Production metallurgy of nuclear grade uranium, thorium beryllium and zirconium; Production of enriched uranium; Processing of spent fuel. Indian reactors and atomic energy program in India. Use of nanomaterials for nuclear application.

Essential Reading:

1. R. Stephenson, ***Introduction to Nuclear Engineering***, Mcgraw-Hill.
2. H. S. Ray, R. Sridhar and K. P. Abraham, ***Extraction of Non ferrous Metals,*** Affliated East-West Press Private Limited.

Supplementary Reading:

1. S. Glasstone and A. Sesonke, ***Nuclear Reactor Engineering***, Van Nostrand

MM 352 MATERIAL CHARACTERIZATION TECHNIQUES 4 Credits [3-1-0]

Chemical bonding, Fundamentals of crystallography, Reciprocal lattice, Structures in metals, Inorganic compounds, Polymers, Silicate glasses, Stereographic projection. Properties of materials; physical, chemical, electrical, optical and magnetic properties. Microscopic and diffraction techniques: Abbe's criteria, Resolution and resolving power of microscope, Rayleigh's criteria of resolution, Optical microscope, Aberrations, Electron interaction with materials. Electron diffraction, Electron microscope, SEM: principle of operation, mode of operation. TEM: principle of operation, sample preparation, mode of operation, advanced microscopic techniques: AFM, STM, EELS. X-ray diffraction: Principle of X-ray diffraction, Bragg's law, structure determination. Thermal characterization techniques: Theory, Thermo Gravimetric Analysis (TGA), Instrumentation, Applications; Differential Thermal analysis (DTA), Apparatus, Methodology, Applications; Differential Scanning Calorimetry (DSC), Applications; Dilatometer. Chemical characterization techniques: Principle underlying techniques, Infrared spectroscopy (IR), Raman spectroscopy, Mossbauer spectroscopy, Nuclear magnetic resonance spectroscopy (NMR), Emission spectroscopy (Chromatography techniques).

Essential Reading:

1. Ruth E. Whan, ***Material Characterization, Metals Handbook, Vol 10,*** ASM, 1986.
2. Elton N Kaufmann, ***Characterization of Materials***, Willey Publishers, 2003.

Supplementary Reading:

1. P. J. Grundy and G. A. Jones, ***The structure and properties of solids,*** Edward Arnold, 1975.
2. B. D. Cullity, ***Elements of X-ray diffraction,*** Addison-Wesley publishing company, 2002.
3. B. M. Rao, ***Chemical characterization of materials***, Himalaya publishing house, 2000.
4. J. I. Goldsetin,, C E. Lyman, D. E. newbury, E. Lifshin, P. Echlin, L. Sawyer, D. C. Joy, j. R. Michael,, ***Scanning electron microscopy and X-ray microanalysis***, 2003. Springer

MM 356 POLLUTION IN METALLURGICAL INDUSTRIES AND ITS CONTROL 3 Credits [3-0-0]

Review of various types of pollutions; air pollution, water pollution, solid waste pollution and noise pollution; Environmental impact assessment in metallurgical industries; Emissions from integrated iron and steel plants and suggestion of equipments for their control; Environmental aspects of sponge iron plants and their effective control; Pollutant emissions from other alternative iron and steelmaking processes and their control. Management of wastes from iron and steelmaking operations; Environmental pollutant emissions from Al, Zn Cu and lead industries; Preventive measures to reduce the atmospheric pollutions from these non-ferrous industries. Environmental legislations related to metallurgical industries.

Essential Reading:

1. C. S. Rao, ***Environmental Pollution Control Engineering,*** Willey Eastern Ltd., 1991.
2. G. N. Pandey & G. C. Carney, ***Environmental Engineering,*** Tata McGraw Hill Publishing Company, 1989.

Supplementary Reading:

1. ***Proceedings of International Conference on Environmental Management in Metallurgical Industries EMMI-2000,*** Allied Publisher, Calcutta.
2. ***Proceeds of International Workshop on Environmental and Waste Management in Iron and Steel Industries,*** Dec 2 – 3, 1999, NML Jamshedpur.

MM 357 CORROSION AND DEGRADATION OF MATERIALS AND THEIR PREVENTION 4 Credits [3-1-0]

Degradation of materials: Oxidation, Corrosion and wear, Basics of thermodynamics and kinetics of oxidation and corrosion, Pourbaix diagram, Polarization, Mixed potential theory, Passivity, Characteristics of passivation, Degradation of composites. Corrosion: Fundamentals of corrosion studies. Different types of corrosion; Atmospheric, galvanic, Pitting, Crevice corrosion, Intergranular and de-alloying, Stress corrosion cracking, Season cracking, Hydrogen damage and radiation damage, Hydrogen embrittlement, Corrosion rate measurement, Weld-decay and knife line attack, Taffel's extrapolation, Oxidation and hot corrosion of materials at high temperature, Kinetics of oxidation, Pilling-Bed worth ratio. Prevention of degradation: Alloying environment, Environmental conditioning, Design modification, Cathodic and anodic protection, Organic and inorganic coating, Inhibitors and passivators, Wear resistant coating. Environmental degradation of composite.

Essential Reading:

1. Fontana & N. D Greens, ***Corrosion Engineering-M. G***, . Mc Graw Hill publishing company, (2006).
2. H. H. Uhlig, John Wiley & Sons, (2000), ***Corrosion & Corrosion control.***

Supplementary Reading:

1. S. N. Banerjee, ***An introduction to science of corrosion & its inhibition***, Oxonian Press Pvt. Ltd., India, (1985).

MM 358	EXPERIMENTAL TECHNIQUES IN MATERIALS ENGINEERING	3 Credits [3-0-0]

Optical Microscopy and Image analyzer: Understanding of image formation, resolution, numerical aperture, magnification, depth of field and depth of focus of a microscope. Quantitative and phase analysis (inclusion, size distribution etc.). X-ray diffraction and analysis: Production and properties of X-rays, X-ray diffraction, Structure factor and intensity calculations. Effect of texture, particle size, micro strain on diffraction lines. Indexing of powder photographs. X-rays florescence: basics and applications in materials science. SEM and FESEM: Principle and applications, Modes of operation, Image formation - plane and fractured surfaces. Microanalysis (EDX, WDS etc.) TEM: Principle and operation. Bright field and dark field images, Sample preparation techniques. Selected area diffraction, Reciprocal lattice and Ewald sphere construction, Indexing of selected area diffraction patterns. Advanced Characterization Techniques: STEM, AFM, Nanoindentation Testing, EELS- Principle and applications. DTA/DSC-TG: Scope and applications in materials science.

Essential Readings:

1. B. D. Cullity, ***Elements of X-ray Diffraction*** (II edition), Addison-Wesley Publishing Co. Reading, USA, 1978.
2. P. J. Goodhew and F. J. Humphreys, Taylor and Francis, ***Electron Microscopy and Analysis,*** London, 2001(ISBN-0-7484-0968-8).

Supplementary Readings:

1. S. H. Cohen and Marcia L. Lightbody (Editors), ***Atomic Force Microscopy / Scanning Tunneling Microscopy***, Plenum Press, New York, 1994.
2. P. J. Haines (Editor), ***Principles of Thermal Analysis and Calorimetry*** Royal Society of Chemistry (RSC), Cambridge, 2002.
3. G. F. Vander Voort, ***Metallography: Principles and Practice*** ASM International, Materials Park, USA, 1984
4. S. Amelinckx, D. van Dyck, J. van Landuyt and G. van Tendeloo (Editors), ***Electron Microscopy: Principles And Fundamentals***, VCH, Weinheim, 1997.
5. C. Suryanarayana and M. Norton, ***X-ray Diffraction, A Practical Approach***, Plenum Press, New York, (1998).
6. ***Metallography and Microstructures, Metals Handbook, Volume 9***, 9th edition, American Society for Metals, Metals Park, Ohio, 1986.
7. ***Materials Characterization, Metals Handbook, Volume 10,*** 9th edition, American Society for Metals, Metals Park, Ohio, 1986.

MM 359	ENGINEERING POLYMERS AND COMPOSITES	4 Credits [3-1-0]

Polymers : Classification of polymerization reaction, semi-crystalline and amorphous polymers, Elastomers, Additives, Fillers, Viscoelasticity, Molecular theory for viscoelasticity, Glass and rubbery states, Glass transition temperature, Crystallinity, Deformation, Mechanical response, High temperature specialty polymers, Polymer liquid crystals; **Composites :** Classification of polymer matrix composites, metal matrix composites, ceramic matrix composites. Determination of Engineering Elastic Constants, Stiffness of composites; Fabrication of composites: PMC; Injection moulding and Liquid resin impregnation route. MMC; Squeeze infiltration and Physical vapour deposition. CMC; Powder based route and reaction processing; Matrix deformation, Interfacial debonding, Effect of microstructure, Interfacial fracture and crack deflection. Fatigue Failure, Stress Corrosion Cracking, Creep, Selection of polymers for design applications of mechanical components.

Essential Reading:

1. D. Hull and T. W. Clyne, ***An introduction to composite material,*** Cambridge University press.
2. Nelson Thomes, Young and Lovell, ***Introduction to Polymers.***

Supplementary Reading:

1. L. E. Nelsen, ***Mechanical properties of polymer and composite***, Publisher CRC, 1993.
2. William W. Callister, ***Materials Science and Engineering***, John Wilely and Sons, 6th Edittion, 2002.
3. S. Suresh, A. Mortensen and A. Needleman, ***Fundamentals of Metal Matrix Composites***, Butterworth- Heinemann.

MM 370	FUEL TESTING LAB.	Credits [0- 0- 3]

General introduction of solid fuels; To determination % moisture and volatile matter contents in coal; To determine the % ash and fixed carbon contents in coal; To determine calorific value of coal; To determine bulk density of coal –

study of the effects of size and moisture addition; To determine apparent density and apparent porosity of coal/coke; To determine true density and true porosity of coal; To determine caking index of coal; To determine the % yield of char on carbonization of non – coking coal.

MM 371 THERMODYNAMICS AND KINETICS LAB. 2 Credits [0- 0- 3]

To determine the tumbler and abrasion indices of lump iron ore; To determine the micuum indices of coke; To study the decomposition of calcium carbonate and determination of equilibrium constant and free energy change; To determine the partial molal volume of each component in a solution of water and methanol; To determine the equilibrium constant and free energy change for the $C + CO_2$ ⍰ 2 CO reaction; To study the effect of temperature on % reduction of iron ore pellet; To study the effect of time on % reduction of iron ore pellet; Pelletization of iron ore fines, firing of pellets and measurement of their crushing strengths.

MM 372 THERMAL ANALYSIS LAB. 2 Credits [0- 0- 3]

To carry out the thermal analysis of Al sample using TG – DSC technique (Melting point and oxidation study); Dilatometric study of given Al plate sample; Thermal analysis of 0. 2% C steel using DSC – TG technique to study Microstructural changes with temperature; Thermal analysis of epoxy polymer using DSC technique (glass transition temperature); Thermal analysis of 0. 2% C steel using DSC – TG technique during (a) heating (b) cooling (c) isothermal holding; Thermal analysis of 0. 8%C cut eutectoid steel sample during heating and to compare it with behaviour shown by 0. 2%C steel during heating; To study the thermal behaviour of Calcite on heating by using DSC – TG technique.

MM 373 MECHANICAL TESTING LAB. 2 Credits [0- 0- 3]

Hardness measurement of metallic materials using Vicker, Rockwell and Brinell hardness testing machines; Microhardness testing of two and / or multiphase alloy systems; Tensile tests of low carbon steel (annealed), high carbon steel (annealed) and a non ferrous alloy; To draw true stress – true strain diagram/s using above data and determination of strain hardening exponent; Compression testing of ceramics, powder metallurgy specimens; Three – point bend test of non – metallic materials; Impact testing of steels / non – ferrous alloys / non – metallic materials; Wear studies of different carbon steels; To develop S – N curve of a metallic specimen; KIC tests of a brittle material.

MM 374 STRUCTURE PROPERTY CORRELATION PROJECT 2 Credits [0- 0- 3]

Heat Treatment, Microstructure examination, mechanical characterization and fractography of medium carbon steel; Study the age hardening behaviour of 2XXX / 7XXX aluminium alloy; Annealing of cold worked metal and study the changes in microstructures, mechanical properties and fractographic features; Effect of inter-critical annealing on tensile behaviour of low carbon steel.

MM 376 COMPUTATIONAL TECHNIQUE IN MATERIALS ENGG. LAB. Credits [0- 0- 3]

Basics of numerical mathematics, Concept of physical domain and computational domain numerical, Integration, Initial value problems, assumptions and limitations in numerical solutions, simulation, instrumentation and data acquisition systems.; To draw a circle using MATLAB; To solve a system of linear equations using MATLAB; To solve an ODE using MATLAB; To find out the standard deviation of a given set of values using MATLAB; Curve fitting techniques using regression and interpolation. Using MATLAB fit a linear curve for given set of data; To draw a sphere using MATLAB and extend the program to draw FCC and BCC crystal structures; To find out the lattice parameter from the XRD data of an element belonging to the cubic system using MATLAB; To create your own design using MATLAB codes.

MM 408 ENERGY, ENVIRONMENT & RECYCLING 3 Credits [3-0-0]

Introduction and potentials of world energy resources: Fossil fuels, Nuclear energy, Biomass energy, Solar energy, Wind energy, Geothermal energy, etc.; Present day energy scenario in the world and India in particular; Consumption of fossil fuels in chemical, metallurgical and power industries and automobiles; Various types of pollutants and their harmful effects; Pollutant emissions from major fossil fuel consuming industries / sectors and their local and global effects; Renewable energy sources – their potentials, possible applications and impact on environmental pollution; World-wide approach in abatement of pollution emissions and conservation of fossil fuels; Solid, liquid and gas wastes generated from metallurgical industries – their recycling, reuse and management; Municipal wastes and their energy potentials; Waste heat recovery; Environmental legislations related to Metallurgical, Chemical and Power industries.

Essential Reading:

1. Prof. R. C. Gupta (Editor), ***Proceedings of the International Conference on Environmental Management in Metallurgical Industries***, 14 – 16th Dec. 2000, Allied Publishers Ltd., New Delhi.

2. Larry L. Anderson and David A. Tillman, ***Fuels from Wastes,*** Academic Press, New York, 1977

Supplementary Reading:

1. Perry Nowacki (Ed.), ***Health Hazards and Pollution Control in Synthetic Liquid Fuel Conversation,*** Noyes Data Corporation, New Jersey, 1980.
2. C. N. Sawyer and P L Mccarty, ***Chemistry for Environmental Engineering,*** 3rdEdn., McGraw-Hill, New York, 1978.

MM 416	COMPLEX FERROUS AND NON-FERROUS ALLOYS	3 credit [3-0-0]

Ferrous alloys: Introduction, Important alloy steels, High speed steels, Stainless steels, Maraging steels, TRIP steels; Alloyed Cast irons, Ni-Hard cast iron, Ni-resist cast iron, High Cr cast iron, High Si cast iron, Austenitic cast irons, Cast irons for high temperature uses.; Non-ferrous alloys: Zinc-based die casting alloys, Ni-Cr-high temperature alloys, Bearing materials; Super alloys: Ni, Co, and Fe based super alloys, Heat treatment important properties and applications of super alloys.

Course Care-taker: Dr. S. Sen

MM 426	SECONDARY STEELMAKING	3 Credits [3-0-0]

Objectives and techniques adopted in Secondary Steelmaking like vacuum degassing processes: ladle degassing processes (VOD, VAD), steam degassing processes, circulation degassing processes (RH, DH). Inert gas purging, ladle furnace, etc. Role of slag and powders in inclusion control; Desulphurization; Dephosphorisation; Modifications of inclusion morphologies, production of ultra low carbon, ultra low sulphur, ultra low phosphorus and inclusion free steels; Powder injection system. Production of stainless steels through VOD, AOD and CLU processes. Production of ultraclean steel through post solidification treatments (VAR, ESR processes); Refractories used in secondary steelmaking furnaces, their properties and selection criteria.

Essential Reading:

1. A. Ghosh, ***Secondary Steelmaking – Principle & Applications***, CRC Press – 2001.

Supplementary Reading:

1. A. Ghosh, ***Principles of Secondary Processing and Casting of liquid steel***, Oxford & IBH Publication.
2. Ahindra Ghosh and Amit Chatterjee, ***Ironmaking and Steelmaking Theory and Practice,*** Prentice-Hall of India Private Limited, 2008

MM 427	SPONGE IRON TECHNOLOGY	3 credit [3-0-0]

Care taker: Dr. M. Kumar

Present and future of sponge iron industries in India; Classification of DR processes; Mechanism of Iron ore reduction in coal- based and gas-based DR processes; Salient features of coal- based (rotary kilns) DR processes; Characteristics of raw materials for use in rotary kilns; Coal-based; processes using reactors other than rotary kilns; Salient features of gas-based DR processes; Strengths and weaknesses of different DR processes particularly in context to India; Properties and usage of DRI; Pollution issues in the Indian DR industries.

MM 428	ADVANCES IN STEELMAKING	4 Credits [3-1-0]

A critical appraisal of hybrid blowing process, UHP electric arc and induction furnaces with respect to raw materials, energy consumption, productivity and product quality; Special grade steels; Development of secondary steelmaking and their importance under Indian conditions; Sources of inclusions; sulphur, phosphorus and gases in steel; Secondary steelmaking technologies; Inert gas purging; Vacuum degassing – RH/DH, VOD, VAD, Ladle furnace; Powder injection system – powder dispenser, lance, etc.; Physicochemical and fluid dynamic aspects of powder injection and stirring processes; Role of slag and powders in inclusion control; Desulphurization; Cored wire feeding; Production of ultra low sulphur, ultra low phosphorus and inclusion free steels, ultra-low carbon steels; modification of inclusion morphologies; Production of stainless steel through VOD, AOD, CLU, processes. Production of ultra clean steel through post solidification treatments (VAR, ESR processes); Selection and properties of refractories for secondary steel technology-slide gate, porous plug, ladle lining, etc.

Essential Reading:

1. A. Ghosh, ***Secondary Steelmaking – Principle & Applications***, CRC Press – 2001.
2. Richard J. Fruehan (ed.), ***The Making, Shaping and Treating of Steel (Steeelmaking Volume),*** The AISE Steel Foundation, 2004.

Supplementary Reading:

1. Ahindra Ghosh and Amit Chatterjee, Ironmaking ***and Steelmaking Theory and Practice,*** Prentice-Hall of India Private Limited, 2008
2. R. G. Ward, ***Physical Chemistry of iron & steel making***, ELBS and Edward Arnold, 1962.
3. F. P. Edneral, ***Electrometallurgy of Steel and Ferro-Alloys***, Vol. 1 Mir Publishers, 1979
4. ***Pre-requisite:*** MM – 321 Ironmaking and MM – 324 Steelmaking

MM 431 MECHANICAL BEHAVIOUR OF MATERIALS 4 Credits [3-1-0]

Tensile Behaviour of Metals: True stress-true strain curve, Strain hardening coefficient, Instability in tension, Effect of strain rate and temperature on flow properties. Fracture: Theoretical cohesive strength of metals, Griffith's theory of brittle fracture, Mechanism of brittle and ductile fracture, Fractographic aspects of fracture, Notch effects. Impact Behaviour: Notched bar impact test, Transition temperature phenomenon, Factors affecting transition temperature; Fracture Mechanics: Strain energy release rate, Stress intensity factor, Plane strain fracture toughness, Design approach; Fatigue: Micromechanisms of crack initiation and growth, Stress and strain approaches of fatigue, Fracture mechanics approach, Fatigue crack growth; Environmental Assisted Cracking: Stress corrosion cracking, Hydrogen embrittlement, Corrosion fatigue. Creep: Creep curves, Mechanisms of creep, Stress rapture test, Life prediction, High temperature alloys. Composites: Fracture and fatigue of composites.

Essential Reading:

1. G E Dieter, ***Mechanical Metallurgy*** –McGraw – Hill Publication (1988).
2. R W Hertzberg, ***Deformation and Fracture Mechanics of Engineering Materials***, John Wiley & Sons Publication (1995).

Supplementary Reading:

1. R E Reed, ***Physical Metallurgy Principals*** —Hill Litton Education Publication (2004).
2. W. Soboyejo, ***Mechanical Properties of Engineering Materials*** –Marcel Dekker Publication (2003).

MM 435 FRACTURE MECHANICS AND FATIGUE OF METALS 4 Credits [3-1-0]

Griffith's crack theory, Strain energy release rate, Stress analysis of cracks and linear elastic fracture mechanics (LEFM), Crack tip plastic zone, Fracture mode transition: plane strain and plane stress fracture toughness, Plane strain fracture toughness determination, Plane stress fracture toughness determination, Fracture toughness determination using ***J***-integral approach. Microstructural aspect of fracture toughness, Optimizing microstructure and alloy cleanliness to enhance fracture toughness. Design approach; Cyclic stress controlled fatigue, Cyclic strain controlled fatigue, Ratcheting behavior of materials; Mechanism of fatigue crack nucleation and propagation, Subcritical crack growth in cyclic loading, Factors affecting fatigue crack growth rate, influence of load interaction and environment. Fatigue crack growth models and life estimation, Short fatigue crack. Failure Analysis and case studies.

Essential Reading:

1. T. L. Anderson, ***Fracture Mechanics fundamental and application***, (CRC Bess) 3rd Ed (2005)
2. R. W. Hertzberg, ***Deformation and Fracture Mechanics of Engineering Materials,*** (John Wiley & Sons Pub.). 4th Ed. (1995)

Supplementary Reading:

1. G. E. Dieter, Mechanical Metallurgy Mc-Graw Hill (1988).
2. D. Broek, ***Elementary Fracture Mechanics***, Martinus Nijho Publisher.
3. ***Metal Handbook, Failure Analysis & Prevention (Vol. - XI)*** (ASM Pub.)
4. ***Metal Handbook, Fractography (Vol – XII)*** (ASM Pub.)

MM 442 ADVANCED MATERIALS 3 Credits [3-0-0]

Electronic Polymers, Organic electronics, Melanin, Organic semiconductor, Printed electronics, Organic LED. Nanostructures, Nanomaterials, Nanocomposites. Biomaterials: Metallic biomaterials like 316L stainless steel, Co-Cr Alloys, Titanium Ti6Al4V**,** Ceramic biomaterials like Alumina, Zirconia, Carbon Hydroxyapatite**,** Polymeric biomaterials likeUltra high molecular weight polyethylene, Polyurethane. Smart Materials: Piezoelectric materials, Shape memory alloys and shape memory polymers. High Performance Alloys: Nickel super alloys, Ti alloys, Al-Li alloys, Hastelloy, Inconel, Monel, Nitronic, Cobalt based alloys and commercially available pure nickel alloys. Functional and Engineering Ceramics: diverse applications as cutting tools, mobile phone microwave devices, polycrystalline diamond and fuel cells. Hybrid Materials: Design, Synthesis and Properties of hybrid materials created by blending disparate materials such as plastics with metals. Processing of Advanced Materials: Superplastic, spray forming, rapid solidification. Materials selection and design.

Essential Reading:

1. Mark J. Hampden-Smith Wiley-VCH, ***Chemistry of Advanced Materials: An Overview Leonard V. Interrante,*** 1st edition (1997) ISBN-10: 0471185906 ISBN-13: 978-0471185901.
2. R E Smallman, A. H. W., Butterworth-Heinemann, ***Physical Metallurgy and Advanced Materials,*** Seventh Edition, 2007, ISBN: 0750669063.

Supplementary Reading:

1. M. Meyers, M Sarikaya, R. Ritchie, Elsevier, ***Nano and Microstructural Design of Advanced Materials,*** 2003, ISBN-13: 978-0-08-044373-7, ISBN-10: 0-08-044373-7.

MM 446	COMPOSITE MATERIALS	4 Credits [3-1-0]

Introduction to Composites, Matrices, Reinforcements, Classifications, Applications, Advantages, Fundamental concept of reinforcement, review of current developments; design & fabrication and economic considerations. Basic mechanics of reinforcement, Stiffness of parallel arrays of fibres in a matrix. Discontinuous and particulate reinforcement. Fibres and resin materials. Rule of Mixtures, Critical Fiber Length, Short and Continuous Fibers, Fiber Orientation Matrix and Reinforcement Materials, Polymeric Matrices, Metallic Matrices, Ceramic Matrices, Particulates, Flakes, Whiskers, Fibers: C, B, Glass, Aramid, Al_2O_3, SiC, Nature and manufacture of glass, carbon and aramid fibres. Review of the principal thermosetting and thermoplastic polymer matrix systems for composites. Polymer Matrix Composites (PMCs), Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs), CFRP & Carbon/Carbon Composites (CCCs). Types, Manufacturing, Processing methods, Interfaces, Properties, Applications, Toughening Mechanisms, Fiber Forms, Prepregs, Molding Compounds-Processes, Lay-Ups, Filament Winding, Pultrusion, Recycling. Matrix–Reinforcement Interface, Wettability, Interactions at Interface, Interfacial Bonding Types, Interfacial Strength Tests, The role of the interface. The nature of fiber surfaces, wetting and adhesion. Strength, Stiffness, Fracture, Toughness and toughening mechanisms of composites. Strengths of unidirectional composites. Multiple fracture in laminates. Macroscopic fracture and energy dissipating processes. Application of fracture mechanics to composite materials. Fracture Mechanics and Fracture Toughness in Composites, Linear Elastic fracture mechanics, Toughness, Fiber matrix de-bonding, Fiber Pullout Buckling and Post-Buckling. Failure criteria, Fatigue and Creep in composites, Environmental effects in Composites, Green composites. Synthesis and Properties of Nanocomposites.

Essential Reading:

1. Chawla, ***Composite Materials: Science and Engineering,*** Springer, 2ndEd. 1998.

Supplementary Reading:

1. Matthews & Rawlings, ***Composite Materials: Engineering and Science***, Chapman & Hall, 1994.
2. Hull, ***An Introduction to Composite Materials***, Cambridge, 2nd Edt. 1997.

MM 448	ADVANCED ENGINEERING MATERIALS	3 Credits [3-0-0]

Electronic Polymers, Organic electronics, Melanin, Organic semiconductor, Printed electronics, Organic LED. Nanostructures, Nanomaterials, Nanocomposites. Biomaterials: Metallic biomaterials like 316L stainless steel, Co-Cr Alloys, Titanium Ti6Al4V, Ceramic biomaterials like Alumina, Zirconia, Carbon Hydroxyapatite, Polymeric biomaterials like Ultra high molecular weight polyethylene, Polyurethane. Smart Materials: Piezoelectric materials, Shape memory alloys and shape memory polymers. High Performance Alloys, Nickel super alloys, Ti alloys, Al-Li alloys, Hastelloy, Inconel, Monel, Nitronic, Cobalt based alloys and commercially available pure nickel alloys. Functional and Engineering Ceramics: diverse applications as cutting tools, mobile phone microwave devices, polycrystalline diamond and fuel cells. Hybrid Materials: Design, Synthesis and Properties of hybrid materials created by blending disparate materials such as plastics with metals. Processing of Advanced Materials, Superplastic, spray forming, rapid solidification. Materials selection and design.

Essential Reading:

1. Overview Leonard V. Interrante, Mark J. Hampden-Smith Wiley, ***Chemistry of Advanced Materials,*** An -VCH; 1st edition (1997) ISBN-10: 0471185906 ISBN-13: 978-0471185901.
2. R E Smallman, A. H. W. Ngan, Butterworth-Heinemann, ***Physical Metallurgy and Advanced Materials,*** Seventh Edition, 2007, ISBN: 0750669063.

Supplementary Reading:

1. M. Meyers, M Sarikaya, R. Ritchie, Elsevier, ***Nano and Microstructural Design of Advanced Materials 2003,*** ISBN-13: 978-0-08-044373-7, ISBN-10: 0-08-044373-7.

MM 449	NANOSTRUCTURED MATERIALS	3 Credits [3-0-0]

Introduction: Types of nanomaterials, Emergence and challenges in nanotechnology. Synthesis routes for nanomaterials: Bottom-up and top-down approaches, Solid, Liquid, Gas phase synthesis, Hybrid Phase synthesis. Synthesis of bulk Nanostructured materials: Approaches and challenges. Properties of nanomaterials: Stability of nanomaterials, Mechanical properties, Optical, Electrical and Magnetic properties, nano-diffusion. Characterization of nanomaterails: Structural characterization by XRD, SEM, TEM, SPM, Chemical characterization by spectroscopy techniques, Characterization of mechanical properties by nanoindentation, Hot compression testing, Fracture analysis. Application of nanomaterials: Electronics and optoelectronics applications, Nanobots, Biological applications, Catalytic applications, Quantum devices, Application of carbon nanotubes, Nanofluids. Future of Nanotechnology.

Essential Reading:

1. Yuri Gagotsi (Ed.), Taylor and Francis, ***Nanomaterails Handbook***, 2006.
2. G. Cao, ***Nanostructures and Nanomaterials***, Imperial College Press, 2006.

Supplementary Reading:

1. R. D. Booker and E. Boysen, ***Nanotechnology for Dummies,*** Dummies Publishing, 2005.
2. C. Delerue and M. Lannoo, ***Nanostructures,*** Springer, 2004.
3. C. P Poole and F. T. Owee, ***Introduction to Nanotechnology***, Willey Press, 2003.

MM 468	JOINING OF METALS	4 Credits [3-1-0]

Introduction: Principle, Theory and Classification of welding and other joining processes. Manual metal arc (MMA): Equipment requirement, electrodes for welding of structural steels, coating constituents and their functions, types of coatings, current and voltage selection for electrodes, Arc welding power sources; Conventional welding transformers, rectifiers and current and voltage. The influence of these power sources on welding. Metal transfer. Submerged arc welding (SAW): Process details, consumables such as fluxes and wires for welding mild steel, Variations in submerged arc welding process. Gas metal arc welding (GMAW) or MIG/ MAG welding: Process details, shielding gases, electrode wires, their sizes, and welding current ranges. TIG welding: Process details, power sources requirements, electrode sizes and materials, current carrying capacities of different electrodes, shielding gases, application of process. Resistance welding: General principle of heat generation in resistance welding, application of resistance welding processes. Process details and working principle of spot, seam, and. projection welding, electrode materials, shapes of electrodes, electrode cooling, selection of welding currents, voltages. Welding metallurgy of carbon and alloy steels, Cast irons, Stainless steels, Al- and Cu-based alloys. Weldability and Heat affected zones (HAZ). Welding defects and detection techniques. Soldering and brazing: Difference between both the processes, consumables used, methods of brazing, fluxes used, their purposes and flux residue treatment.

Essential Reading:

1. J F Lancaster, Allen and Unwin, ***Metallurgy of Welding.***
2. R L Little, ***Welding and Welding Technology***, TMH.

Further Reading:

1. J Norrish, Woodhead, ***Advanced Welding Processes.***
2. K Weman, Woodhead. ***Welding Processes Hadbook.***

MM 471	COMPOSITE MATERIALS LAB.	2 Credits [0- 0- 3]

Fabrication of FRP composite specimen in the laboratory by hand laying method using epoxy resin and e-glass fibers; Cutting out the test specimen using diamond cutter from FRP composite sheets and determination of the moisture intake by test specimen during atmospheric curing; 3-point bend test of the FRP composite test specimen fabricated in the laboratory using Instron – 1195; Post-curing effect (Temperature, UV radiation) on mechanical properties of FRP composite by 3-point bend test; Fabricated of MMC (Al-SiC) composite specimen in the laboratory with varying fraction of reinforced particle by powder metallurgy route (minimum 3 compositions); Effect of variation of reinforced phase fraction on microstructure and mechanical properties (hardness/microhardness etc.) of MMC; Study of microstructure and mechanical properties (hardness/microhardness etc.) of MMC produced by casting route and comparison with that produced my powder metallurgy route; Study of fracture surface of MMC/CMC by scanning electron microscopy and analysis of fracture mechanism.

MM 472	MODELING OF MATERIALS PROCESSES	2 Credits [0- 0- 3]

Modeling of experimental data from literature based on process Metallurgy; Modeling of data from literature based on physical Metallurgy and/ or mechanical metallurgy; Modeling of data from literature on non-metallic materials

MM 473	DESIGN & CALCULATION LAB.	2 Credits [0- 0- 3]

Design of Blast Furnace; Blast Furnace charge calculation; Heat balance of Iron Blast Furnace; Heat balance of Blast Furnace Stove; RAFT (Raceway Adiabatic Flame Temperature) Calculation; Design of a L. D. Vessel; Heat balance of a Composite Steel Slab Reheating Furnace; Calculation the thickness of the solidified shell at the mould exit in a Continuous Casting Unit.

DEPARTMENT OF MINING ENGINEERING

DETAILED SYLLABI OF COURSES

MN 201	Mine Development	3-1-0	4
MN 202	Mine Surveying	3-1-0	4
MN 203	Basic Surveying	3-0-0	3
MN 204	Mining Machinery	3-0-0	3
MN 205	Mineral Exploration	3-0-0	3
MN 206	Introductory Mining Technology	3-0-0	3
MN 207	Mining Geology	3-0-0	3
MN 208	Geostatistics	3-0-0	3
MN 232	Solid fuel Technology	3-0-0	3
MN 271	Mine Surveying Laboratory	0-0-3	2
MN 273	Mining Geology & Exploration Laboratory	0-0-3	2
MN 274	Mining Machinery Laboratory	0-0-3	2
MN 301	System Engineering	3-0-0	3
MN 302	Mine Economics	3-1-0	4
MN 303	Material Handling Systems	3-0-0	3
MN 304	Computer Application in Mining	3-1-0	4
MN 305	Mineral Processing Technology	3-0-0	3
MN 311	Surface Mining Technology	3-1-0	4
MN 313	Underground Mining Technology	3-1-0	4
MN 321	Rock Mechanics	3-1-0	4
MN 322	Geomechanics	3-1-0	4
MN 323	Rock Engineering	3-0-0	3
MN 324	Strata Control Technology	3-1-0	4
MN 325	Ground Control Instrumentation	3-1-0	4
MN 330	Mine Ventilation	3-1-0	4
MN 331	Solid Fuel Technology	3-0-0	3
MN 332	Remote Sensing and Its Application	3-1-0	4
MN 336	Solid Fuels and Clean Coal Technology	3-0-0	3
MN 370	Mine Ventilation Laboratory	0-0-3	2
MN 371	Rock Mechanics Laboratory	0-0-3	2
MN 372	Computer Application in Mining Laboratory	0-0-3	2
MN 373	Mineral Processing Technology Laboratory	0-0-3	2
MN 374	Geomechanics Laboratory	0-0-3	2
MN 375	Material Handling Systems Laboratory	0-0-3	2
MN 376	Model Preparation Laboratory	0-0-3	2
MN 377	Solid Fuel Technology Laboratory	0-0-3	2
MN 400	Mine Planning	3-1-0	4
MN 410	Tunneling	3-1-0	4
MN 411	Advanced Surface Mining	3-1-0	4
MN 412	Mining of Deep Seated Deposits	3-1-0	4

MN 413	Advanced Coal Mining	3-1-0	4
MN 414	Rock Mechanics Application to Environmental Problems	3-0-0	3
MN 415	Advanced Metaliferrous Mining	3-1-0	4
MN 421	Rock Slope Technology	3-0-0	3
MN 431	Mine Environmental Engineering	3-1-0	4
MN 433	Environmental Impact Assessment	3-0-0	3
MN 435	Eco-friendly Mining	3-1-0	4
MN 436	Environmental Pollution and Control in Mines	3-1-0	4
MN 438	Solid Waste Management	3-0-0	3
MN 441	Mine Legislation and Safety Engineering	3-1-0	4
MN 442	Mine Fires and Spontaneous Heating	3-1-0	4
MN 451	Mine Management	3-1-0	4
MN 471	Mine Environmental Engineering Laboratory	0-0-3	2
MN 472	Mine Planning and Design Laboratory	0-0-3	2
MN 473	Simulation and Modeling of Mining Systems Laboratory	0-0-3	2

For B. Tech Courses (3 or 4 level) please refer to the B. Tech Curriculum and Syllabi, for M. Tech Courses (6 level) please refer to M. Tech Curriculum and Syllabi.

MN 201 MINE DEVELOPMENT 4 credits [3-1-0]

Introduction: Distributions of mineral deposits in India and other countries, mining contributions to civilization, mining terminology, stages in the life of the mine - prospecting, exploration, development, exploitation and reclamation, access to mineral deposit- selection, location, size and shape (incline, shaft and adit), brief overview of underground and surface mining methods.; Drilling: Types of drills, drilling methods, electric, pneumatic and hydraulic drills, drill steels and bits, drilling rigs, and jumbos.; Explosives: Classification, composition, properties and tests, fuses, detonators, blasting devices and accessories, substitutes for explosives, handling and storage, transportation of explosives.; Rock blasting: Mechanism of rock blasting, blasting procedure, and pattern of shot holes.; Shaft sinking: Ordinary and special methods, problems, and precautions, shaft supports and lining.

Essential Reading:

1. R. P. Pal, A. A. Balkema, ***Rock blasting effect and operation***, 1st Ed, 2005.
2. D. J. Deshmukh, ***Elements of mining technology***, Vol. 1, Central Techno Publications, Nagpur, 7th Ed, 2001

Supplementary Reading:

1. B. H. Gary, ***Blasting operations***, Mc-graw Hill, 1st ed, 1981.
2. R. P. Pal, ***Blasting in ground excavations and mines***, Oxford and IBH, 1st Ed, 1993.
3. C. P. Chugh, ***Drilling technology handbook***, Oxford and IBH, 1st Ed, 1977.
4. R. D. Singh, ***Principles and practices of modern coal mining,*** New age international**,** 1st Ed, 1997.
5. S. K. Das, ***Explosive and blasting practices in mines***, Lovely prakashan, 1st Ed, 1993.
6. P. K. Rajameny, A Joshi, and S. Bhandari, ***Blast design and Practice***, Himanshu Publications, Udaypur, 2006.

MN 202 MINE SURVEYING 4 credits [3-1-0]

Linear measurement, Compass surveying – use of prismatic compass, bearing of a line, dial traverse and adjustments, local attractions and correction of bearings, Theodolites- seconds theodolites, micro-optic theodolites, electronic theodolites, measurement of horizontal angles by repetition method and re-iteration method and measurement of vertical angles by general method; Traversing – surface and underground including boundary surveys and joint surveys, survey errors and their adjustments, co-ordinate calculations. . Leveling- use of dumpy levels, quick setting levels, digital levels and leveling staff, temporary adjustments of levels, ordinary and precise leveling, reduction of levels by height of instrument method and rise and fall method, reciprocal leveling, profile leveling, differential leveling; Triangulation: Classification of Triangulation systems, Triangulation figures, Base line measurements; Correlation of surface and underground surveys: Verticality of shafts, measurement of depth of shafts, setting out curves – surface and underground. Special Mine Surveys: Surveys for connecting national grid, survey of installations of mine structures, EDM and its application, Surveying by Modern instruments by using GPS & Total Station.

Essential Reading:

1. W. Schofield and M. Breach, ***Engineering Surveying***, Sixth edition, 2007, ELSEVIER, B & H.
2. B. C. Punmia, ***Surveying, Vol - I, II, III***, Laxmi Publication, New Delhi, 12th Edition, 1990.

Supplementary Reading:

1. V. Maslov, ***Geodetic Surveying***, Mir Publication, Moscow, Revised edition, 1980.
2. Fedorov, ***Elementary Plane and Mine Surveying***, Mir Publication, Moscow, Revised Edition, 1986.
3. V. Natarajan, ***Advanced Surveying***, B. I. Publication, Bombay, First edition, 1976.
4. T. P. Kanetkar, ***Surveying and Levelling***, Pune Vidyarthi Griha Prakashan, Reprints, 1995.
5. S. K. Roy, ***Fundamentals of Surveying***, Printice Hall of India Pvt., New Delhi, Third Printing, 2004.

MN 203 BASIC SURVEYING 3 credits [3-0-0]

Linear measurements and chain surveying: Errors due to incorrect chain, tape corrections, Compass surveying: Use of prismatic compass – dial traverse and adjustments, bearing of a line, local attractions and corrections for bearings, Theodolites: Seconds theodolites, micro-optic theodolites, electronic theodolites, temporary adjustments, Measurement of horizontal angles by repetition method and re-iteration method, measurement of vertical angles by general method, Traverse surveying: close traverse and open traverse, checks in closed traverse and open traverse, plotting a traverse surveying, consecutive co-ordinates: latitudes and departures, closing error, balancing a traverse, Omitted measurements, Leveling: Use of dumpy levels, micro-optic levels, quick setting levels, digital levels and leveling staff, temporary adjustments of levels, Reduction of levels by height of instrument method, and rise and fall method, ordinary and precise leveling, differential leveling, profile leveling, reciprocal leveling, Survey errors and their adjustments, Co-ordinate Calculations; Triangulation: Classification of Triangulation systems, Triangulation figures, Base line measurements; EDM and its application, Surveying by Modern instruments such as GPS & Total Station.

Essential Reading:

1. B. C. Punmia, ***Surveying, Vol- I, II, III***, Laxmi Publication, New Delhi, 12th Edition, 1990.
2. W. Schofield and M. Breach, ***Engineering Surveying***, sixth edition, ELSEVIER, B & H. 2007,

Supplementary Reading:

1. V. Maslov, ***Geodetic Surveying***, Mir Publication, Moscow, Revised edition, 1980.
2. Fedorov, ***Elementary plane and mine surveying***, Mir Publication, Moscow, Revised edition, 1986.
3. V. Natarajan, ***Advanced Surveying***, B. I. Publication, Bombay, First edition, 1976.
4. T. P. Kanetkar, ***Surveying and Levelling,*** Pune vidyarthi Griha Prakashan, Reprints, 1995.
5. S. K. Roy, ***Fundamentals of Sueveying***, Prentice Hall of India Pvt., New Delhi, Third Printing, 2004.

MN 204 MINING MACHINERY 3 credits [3-0-0]

General: Mechanical transmission of power in mining machinery, shafts, pulleys, gears, and gear/trains, belt drives, chain drives, couplings and clutches, brakes.; Wire ropes: Constructions, examinations, listing and maintenance.; Rope and Locomotive haulages: Direct, main and tail, balanced double drum and endless haulage, gravity haulage, constructional features, power calculation, selection of haulage ropes, haulage tracks and safety appliances, tubs and mine cars, diesel, battery and trolley wire locomotives, tractive effort, ideal gradient, power calculations, exhaust conditioners.; Compressor and pumps: Generation, distribution and use of compressed air in mines, mine pumps, pumping ranges, and fittings, elements of pipe line transportation.; Hydraulics and mining machines: Power hydraulics, hydraulic circuits, actuators, hydraulic fluids, control of hydraulic power, cutting and mining machines for coal, surface coal/ore handling plant.

Essential Reading:

1. D. J. Deshmukh, Elements of mining technology, Vol. 3, Vidyasewa, 3rd ed, 1989.
2. N. T. Karlein, Mine transport, Orient Longman, 1st ed, 1967.

Supplementary Reading:

1. C. F. Statham, ***Coal mining practice***, Caxton Eastern, 1st Ed, 1960.
2. R. D. Singh, ***Principles and practices of modern coal mining***, New age international, 1st ed, 1997.
3. S. K. Das, ***Modern coal mining technology***, Lovely prakashan, 2nd Ed, 1994.
4. M. P. Alexandrov, ***Material handling equipment,*** MIR, 1st ed, 1981.

MN 205	MINERAL EXPLORATION	3 credits [3-0-0]

Classification of ore reserves: proved, probable, and geologist's ore. Geological aspects of drilling borehole location, planning of drilling operations, borehole surveys, correction of deviated boreholes and directional drilling, core-sampling and assaying; Economic classification of mineral resources: calculation of in-situ reserves from borehole data. Underground sampling and calculation of blocked reserves; Exploration: Theory and application of various methods in mineral exploration, Seismic, Gravity and Magnetic methods Principles and methods of gravity and magnetic prospecting, instrumentation, data processing, interpretation with case studies, Fundamentals of remote sensing and its application in large scale mineral exploration. Exploration for oil and natural gas.

Essential Reading:

1. W. C. Peters, ***Exploration and Mining Geology***, Wiley, 2 editions, 1987.
2. P, Kearey, M. Brooks and I. Hill, ***An Introduction to Geophysical Exploration***, Wiley-Blackwell; 3rd edition, 2002.

Supplementary Reading:

1. C. J. Moon, M. K. G. Whateley, A. M. Evans and W. L. Barrett, ***Introduction to Mineral exploration***, Blackwell Publishing, 2006.
2. R. E. Sheriff and L. P. Geldart, ***Exploration Sysmology***, Cambridge University Press; 2 edition, 1995.
3. H. L. Hartman, ***SME Mining Engineering Handbook,*** Society of Mining and Metallurgy and Exploration (US), 1992, 2394 pages.
4. R. Marjoribanks, ***Geological methods in Mineral exploration and Mining***, Springer; 1st edition, 1997.

MN 206	INTRODUCTORY MINING TECHNOLOGY	3 credits [3-0-0]

Introduction: Distributions of mineral deposits in India and other countries, mining contributions to civilization, mining terminology, stages in the life of the mine - prospecting, exploration, development, exploitation and reclamation, access to mineral deposit- selection, location, size and shape (incline, shaft and adit), brief overview of underground and surface mining methods.; Drilling: Types of drills, drilling methods, electric, pneumatic and hydraulic drills, drill steels and bits, drilling rigs, and jumbos.; Explosives: Classification, composition, properties and tests, fuses, detonators, blasting devices and accessories, substitutes for explosives, handling and storage, transportation of explosives.; Rock blasting: Mechanism of rock blasting, blasting procedure, and pattern of shot holes.; Shaft sinking: Ordinary and special methods, problems, and precautions, shaft supports and lining.

Essential Reading:

1. R. P. Pal, ***Rock blasting effect and operation***, A. A. Balkema, 1st Ed, 2005.
2. D. J. Deshmukh, ***Elements of mining technology***, Vol. 1, Central techno, 7th ed, 2001

Supplementary Reading:

1. B. H. Gary, ***Blasting operations,*** Mc-graw Hill, 1st Ed, 1981.
2. R. P. Pal, ***Blasting in ground excavations and mines***, Oxford and IBH, 1st Ed, 1993.
3. C. P. Chugh, ***Drilling technology handbook***, Oxford and IBH, 1st Ed, 1977.
4. R. D. Singh, ***Principles and practices of modern coal mining***, New age international, 1st Ed, 1997.
5. S. K. Das, ***Explosive and blasting practices in mines***, Lovely prakashan, 1st Ed, 1993.

MN 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.

MN 208	Geostatistics	3 credits [3-0-0]

Introduction to geostatistics, Univariate description: Frequency Tables and Histograms, Normal and lognormal Probability plots, Summary of statistics, Measure of Spread, Measure of Shape; Bivariate description: Comparing of two distribution, Scatter plots, Correlation, Linear regression, Conditional Expectation; Spatial Description: Contour maps, Indicator maps, Moving window statistics, Proportional effect, Spatial continuity, h-scatter plots, correlation functions, covariance function and variograms, cross h-scatter plots; Random function, From statistics to Geostatistics, Modeling sample variograms, Regionalised variables; Global estimation: Polygonal declustering, cell declustering, comparison of declustering methods; Point estimation: Polygon, triangulation, inverse distance methods, search neighbourhoods; Kriging: Ordinary kriging, simple kriging; Block Kriging; Search strategy; crossvalidation; Variance volume relationships, change of support: Practical importance of support effects, effect of support on summery statistics, correcting for support effect, transforming from one distribution to another, affine correction, indirect lognormal correction, dispersion variance, estimating dispersion variance from a variogram model; assessing uncertainty; Multivariate geostatistics, Geostatistics for quality control, grade tonnage curve, Basics of non-parametric geostatistics, Indicator Kriging, Brief idea about geostatistical simulation, Introduction to GEOEAS/ GSLIB/SURPAC software.

Essential Reading:

1. E. H. Isaaks and R. M. Srivastava, ***An Introduction to Applied Geostatistics***, Oxford University Press, USA, 1990.
2. J. M. Rendu, ***An Introduction to Geostatistical Methods of Mineral Evaluation*** (Geostatistics), South African Institute of Mining and Metallurgy, 1978.

Supplementary Reading:

1. A. J. Sinclair and G. H. Blackwell, ***Applied Mineral Inventory Estimation***, Cambridge University publication, 2002.
2. B, D. Ripley, ***Spatial Statistics (Wiley Series in Probability and Statistics)***, Wiley-Interscience, New edition, 2004.
3. P. Goovaerts, ***Geostatistics for Natural Resources Evaluation***, Oxford University Press, 1997.

MN 271	MINE SURVEYING LABORATORY	2 credits [0-0-3]

Prismatic Compass Surveying: (a) Bearing of the lines (b) Traversing; Levelling: (a) Precise Levelling (b) Profile Levelling; Plane Table Surveying: (a) Intersection Methods (b) Radiation Method; Theodolite Traversing; Theodolite: (a) Horizontal angle measurement (b) Vertical angle measurement; Signs and Conventions used by the GSI, MMR and CMR; Triangulation Survey: (a) By 1” Theodolite (b) By Electronic Theodolite; Triangulation Survey (a) By EDM (b) By Total Station; Distance Measurement: (a) By EDM (b) By Total Station; Coordinate Measurement: (a) By Total Station (b) By GPS; Traversing and Recording Position of points by GPS; Special Mine Surveys – Surveys for connecting National Grid, Survey of installations of Mine Structures

MN 273	MINING GEOLOGY & EXPLORATION LABORATORY	2 credits [0-0-3]

Identification of common rocks; Identification of common Minerals; Study of physical properties of minerals; Determination of strike and dip; Identification and stereographic plotting of joints; Study of topographic maps; Drawing of geological section; Geological maps with folds and faults; Study of geophysical exploration equipment - resistivity meter; Study of aquameter; Study of magnetometer; Geological field trips

MN 274	MINING MACHINERY LABORATORY	2 credits [0-0-3]

Study of jack hammer drill; Study of different types of wire rope & their uses; Study of different types of rope clips; Study of reliance rope capel; Study of different types of roof bolts; Study of Sylvester prop withdrawal; Study of different types of brakes; Study of different types of Clutches; Study of different parts & functions of an electric coal drill; Study of direct rope haulage; Study of endless rope haulage; Study of main & tail rope haulage.

MN 301	System Engineering	3 credits [3-0-0]

Introduction: Concept of system engineering, General model selection; Data collection: Data collection methods, time study, work sampling, sample number calculation; System analytical techniques: Statistical methods, control charts – X bar chart, R chart, S chart; Mathematical methods for loading and hauling; Stochastic models: Monte Carlo simulation, Activity oriented simulation, process oriented simulation; Reliability: Concepts of reliability, concept of different distribution: Normal, exponential, Beta, Gamma, Binomial, lognormal etc.; fitting a distribution to data, reliability of series and parallel systems, reliability analysis of a combined series parallel system; Optimization and design: Heuristic technique, Dynamic programming, network flow theory, Graph theory; Programming: Linear programming, transportation and assignment problems, Mixed integer linear programming, queuing theory, network analysis, inventory control and simulation techniques.; Analysis: Analysis of exploration and mining systems using mathematical programming, simulation techniques and network models; stochastic model simulation; Concept of Artificial Intelligence: Natural language understanding, Machine vision, robotics, expert system.

Essential Reading:

1. Bernel & Krako, ***Introduction to System Analysis***, A. A. Balkema, 2004.
2. N. Deo, ***System Simulation by Digital Computers***, Prentice Hall of India, 2005

Supplementary Reading:

1. W. Donald Boyd, ***System analysis and modeling,*** Academic Press, 2001.

MN 302	MINE ECONOMICS	4 credits [3-1-0]

Examination of Mineral properties, Mine sampling, estimation of reserves and grades, Impurities and quality control, commercial uses of minerals and ores; Mine valuation. Depreciation methods; decision trees, Mineral Industry of India,; National Mineral Policies, conservation, taxation, trading, mining entrepreneurship, Principles of company law, shares and debentures; joint stock company and public company; partnership business, capital formation, Cost-Volume-Profit analysis and break-even analysis, budgetary control, wages and incentives, purchases, stores and inventory control, sales and despatches.

Essential Reading:

1. R. T. Deshmukh, ***Mineral and Mine Economics***, Myra Publ., Nagpur, 1986
2. R. K. Sinha and N. L. Sharma, ***Mineral Economics***, Oxford & IBH Pub., 3rd ed, 1970

Supplementary Reading:

1. O. P. Khanna, ***Industrial Engineering and Management***, Dhanpat Rai Delhi, 1993
2. R. N. P. Arogyaswamy, ***Courses in Mining Geology***, Oxford and IBH Pub., 2nd ed, 1973
3. S. Krishnaswamy, ***India's Mineral Resources***, Oxford & IBH pub., 2nd ed, 1972
4. P. K. Jain, ***Financial management***, Tata McGraw Hill, 1981

MN 303	MATERIAL HANDLING SYSTEMS	3 credits [3-0-0]

Mine hoist: Drum and koepe winders, constructional features, kinematics, torque and power calculation, speed control, safety contrivances, selection of mine winders, cages, skip, suspension gears, headgear structures, cage guides, pit top and pit bottom circuits and layouts; Conveyors: Belt conveyor, chain conveyor, cable belt conveyor, shaker conveyor, vibratory conveyor, constructional features and power calculations, selection and application; Aerial Ropeway: Mono-cable, bi-cable, twin-cable ropeway, constructional features and power calculations, selection and application; Scraper Haulage: Constructional features, applicability, advantages and disadvantages; Men and material transportation: Trackless vehicle loaders, shuttle cars, SDL and LHD, special men and materials transport in mines, men riding systems in mines.;

Essential Reading:

1. M. A. Ramlu, ***Mine hoisting,*** Oxford and IBH, 1st ed, 1996.
2. D. J. Deshmukh, ***Elements of mining technology***, Vol-III, Vidyasewa, 3rd ed, 1989

Supplementary Reading:

1. N. T. Karlein, ***Mine transport***, Orient Longman, 1st ed, 1967
2. S. C. Walker, ***Mine winding and transport*** (Advances in mining science and technology), Elsevier Science Publishing Company, 1st ed, 1988
3. N. Mukherjee, ***Materials handling in mines***, Technology mining society IIT Kharagpur, Vol- XI, 1sted, 1979-80
4. B. Norman, ***Mechanics of bulk material handling***, London Butterworths, 1st ed, 1971
5. M. P. Alexandrov, ***Material handling equipment***, MIR, 1st ed, 1981

MN 304	COMPUTER APPLICATION IN MINING	4 credits [3-1-0]

Introduction to structure terminology and peripherals, algorithms, flow charts, programs, dedicated systems.; Application in Mining: Exploration, rock topographic models, bore hole compositing, compositing, ore reserve calculation, interpolation and geostastical models.; Open pit design: Ultimate pit design, introductory process control, underground mine design: Production scheduling; Operation Simulation: Introduction, Simulation overview, objective, understand the role of modeling, Understanding the basic concept in simulation; Example of simulation in mining aspects: Simulation of machine repair problems, Concepts of variability and prediction, Example with dumping time problem, fitting distribution with chi-square test; Random number generation: Methods of random number generation, Properties of random number, pseudorandom number; Random variates generation: Methods of random variates generation, inverse transformed method, acceptance rejection method, composition method, empirical method and rectangular approximation; Simulation languages: GPSS, SLAM; Logical flow diagram of different mining activities, Coding with GPSS and SLAM of different mining problems; Computer Control: Remote control, automatic control, application and limitations of control.

Essential Reading:

1. T. C. Bartee, ***Digital Computer Fundamentals***, Mc GRAW HILL, 4th Ed., 1984.
2. P. Malvino and D. P. Leach, ***Digital principles and application***, McGraw-Hill, 5th Ed., 1994

Supplementary Reading:

1. R. V. Ramani, ***Application of computer methods in the mineral industry***.

MN 305	MINERAL PROCESSING TECHNOLOGY	3 credits [3-0-0]

General Principle: Mineral Beneficiation and its role in mineral exploitation.; Comminution and Liberation : Theory and practice of crushing and grinding, performance and choice of crushers and grinding mills. Laboratory techniques, interpretation and plotting of date, Industrial screens and screening efficiency; concentration: Theory and practice of classification, classifiers- Their performance and choice, Picking and washing techniques. Theory and application of sink and float, jigging and flowing film concentration- methods and equipment used; Froth Flotation: Physico-chemical principles, flotation reagents, flotation machines and circuits, application to common sulphides, oxides and oxidized minerals. Electrostatic and Electro-magnetic Separation - Principles, operations and fields of applications.; Flow Sheets: Simplified flow sheets for the beneficiation of beach sand, coal and typical ores of copper, lead, zinc and manganese with special reference to Indian deposits.

Essential Reading:

1. A. M. Gaudin, ***Principles of Mineral Dressing***, Tata McGraw & Hill, 1939
2. R. H. Richard and C. E. Locky***, A text Book on Ore Dressing***, A A Balkema, 2004

Supplementary Reading:

1. F. Taggart, ***Mineral Dressing Handbook***, P & H, 2000
2. B. A. Wills, ***Mineral Processing Technology***, Willy & Sons, 2005
3. G. C. Lowrison, ***Crushing & Grinding***, Maxwell and MacMillan, 2002
4. L. Svalovsky, ***Solid Liquid Separation***, Tata McGraw & Hill Inc., 2003

MN 311	SURFACE MINING TECHNOLOGY	4 credits [3-1-0]

Introduction: Applicability and limitations, Stripping Ratio, Preliminary evaluation of surface mining projects.; Surface Mining Methods: Development of Mineral deposits by opencast mining, design and layout of opencast mines. Methods of stripping, Bench geometry, Bench slope. Drilling, blasting, loading and transportation in opencast mines, Equipment used for different operations, Choice and their application.; Placer Mining and Sea bed Mining: Ground sluicing, Hydraulicking and Dredging. Exploitation systems of ocean mineral resources. Relevant provisions of coal mines and metalliferous mines regulations.; Environmental problems due to surface mining and their remedial measures, Recent developments in the deployment of heavy earth moving machineries in the surface mines.

Essential Reading:

1. G. B Mishra, ***Surface Mining***, Lovely prakashan Dhanbad, 2nd ed, 2006.
2. K Raj. Singhal, ***Mine Planning and Equipment Selection***, A. A. Balkema Rotterdam, 1st ed, 1995.

Supplementary Reading:

1. S. K. Das, ***Surface Mining Technology***, Lovely prakashan Dhanbad, 1st ed, 1994.
2. V. V. Rzhevsky, ***Opencast Mining Unit operations***, Mir Pub., Mascow, 1985.
3. W. Hustrulid and M. Kuchta, ***Open pit mine planning and Design***, Vol-I, A. A. Balkema Rotterdam, 1st ed, 1995.
4. Rozgonyi, G Tibor, ***Continuous surface Mining***, A. A. Balkema Rotterdam, 1st ed, 1988.
5. Crawford, T. John, ***Open pit mine planning and Design***, American Institute of Mining, Metallurgical and Petroleum Engineers, 1979.

MN 313 UNDERGROUND MINING TECHNOLOGY 4 credits [3-1-0]

Development of Stratified Deposits: Choice of mine size, methods of entry and primary development.; Underground Coal Mining Methods: Classification and choice, Bord and Pillar mining, development and extraction, Long-wall mining, face mechanization, production equipment and face machinery used, viz. coal cutting machines, drills, mechanical loaders, LHDS, shuttle car etc. – their performance and choice. Special coal mining methods.; Underground Metal Mining Methods: General Development of property level, crosscuts, raises and winzes, drifting and tunneling, U/g metalliferrous mining methods – their classification and choice. Stoping of ore bodies, supporting and development of stopes Special techniques of mining mechanization. Mining equipment and production machine used below ground. Provision of MMR 1961.; Supports: Roadway and face supports, supports for junctions and special conditions, setting and withdrawal of supports, roof bolting, roof stitching, systematic supporting, protective of pillars.; Stowing and Filling Methods, gathering and transportation arrangements, stowing plants and layout. Provision of CMR 1957.

Essential Reading:

1. T. N. Singh, ***Underground winning of Coal***, Oxford and IBH New Delhi, 1992
2. Y. P. Chacharkar, ***A study of Metalliferous Mining Methods***, Lovely prakshan Dhanbad, 1994

Supplementary Reading:

1. I. C. F. Statham, ***Coal Mining Practice,*** Caxton eastern agencies, Calcutta, Reprint, 1964
2. D. J. Deshmukh, ***Elements of Mining Technology***, Vol - I & II, EMDEE publishers Ranchi, Revised edition, 2000
3. S. K. Das, ***Modern Coal Mining Technology***, Lovely prakshan Dhanbad, 1992
4. R. D. Singh, ***Principles & Practices of Modern Coal Mining***, New age international New Delhi, 1997
5. B. C. Arthur, ***SME Mining EngineersHand Book***, American Institute of Mining, Metallurgical and Petroleum Engineers New York, 1973

MN 321 ROCK MECHANICS 3 credits [3-0-0]

Introduction: Structural Features of rock material and rock mass; Physico mechanical properties: Physical and mechanical properties including swelling potential, different strength parameters and their determination, Hydraulic properties of rocks and determination; Elastic and Time dependent properties of rock: Rock Deformability and its measurement. Elastic and non-elastic behavior, influence of time on rock properties; Theories of rock failure: Rock Strength, Analysis of Stress-Strain Curve, Rock failure and different failure criteria. Effect of anisotropy on rock strength; Stress: Fundamentals of stress and strain in two and three dimension, Stress-Strain relationships, Mohr's circle, Rock mass classification Systems and their interpretation, Rock Support and Design.

Essential Reading:

1. R. E. Goodman, ***Introduction to Rock Mechanics,*** John Wiley and Sons, 1980
2. V. S. Vutukuri and K. Katsuyama, ***Introduction to Rock Mechanics***, Industrial Publishing & Consulting Inc., Tokyo, 1994

Supplementary Reading:

1. B. H. G. Brady and E. T. Brown, ***Rock Mechanics for Underground Mining***, George Allen and Unwin Ltd., 1992
2. J. C. Jeager and N. G. W. Cook, ***Fundamentals of Rock Mechanics,*** Chapman and Hall, 1979
3. L. Hartman, ***Mining Engineering Handbook***, Society for Mining, Mettalurgy and Exploration Inc., USA, 1992
4. J. A. Hudson and J. P. Harrison, ***Engineering Rock Mehcanics***, Pergamon Press, UK, 2000

MN 322 GEOMECHANICS 4 credits [3-1-0]

Rock Stress: Stresses around mine openings of different cross-sections, Insitu Stress- Determination of insitu rock mass properties, insitu testing methods and instrumentations.; Design of underground workings: Pillar Design including applicability of Wilson's approach, Safety factors; Slope Stability: Slope failure types, mechanisms and theories.; Rock Reinforcement and Support: Mechanisms of failure in rock structures-intact and anisotropy, Rock Load and stability, Supporting and reinforcement members, Design of support and reinforcement systems; Mine Subsidence: Subsidence mechanisms and control measures, Basics of numerical methods in geomechanics and applications

Essential Reading:

1. R. E. Goodman, ***Introduction to Rock Mechanics***, John Wiley and Sons, 1980
2. V. S. Vutukuri and K. Katsuyama, ***Introduction to Rock Mechanics,*** Industrial Publishing & Consulting Inc., Tokyo, 1994

Supplementary Reading:

1. B. H. G. Brady and E. T. Brown, ***Rock Mechanics for Underground Mining***, George Allen and Unwin Ltd., 1992
2. J. C. Jeager and N. G. W. Cook, ***Fundamentals of Rock Mechanics***, Chapman and Hall, 1979

3. L. Hartman, ***Mining Engineering Handbook***, Society for Mining, Metallurgy and Exploration Inc., USA, 1992
4. E. Hoek and J. Bray, ***Rock Slope Engineering***, 3rd Ed., Inst. Of Mining and Metallurgy, London, 1980
5. J. A. Hudson, ***Comprehensive Rock Engineering***, Pergamon Press, UK, 2000

MN 323	ROCK ENGINEERING	3 credits [3-0-0]

Introduction: Importance of rock mechanics, rock working, judgment and approximation; Ground Characterisation: Character of rock materials, rock mass, ground water, stress, site investigation; Measurement, Prediction and Monitoring of Rock Behaviour: Design Methods, Strength, Deformability, viscous, thermal and swelling behaviour, Behaviour of discontinuities, monitoring; Rock Excavation and Stabilisation: Blasting, drilling, breaking and cutting, rock reinforcement, support and lining systems, drainage and grouting

Essential Reading:
1. J. A. Franklin and M. B. Dusseault***, Rock Engineering,*** McGraw-Hill, Inc., 1991
2. R. E. Goodman, ***Introduction to Rock Mechanics,*** John Wiley and Sons, 1980

Supplementary Reading:
1. L. Hartman, ***Mining Engineering Handbook***, Society for Mining, Metallurgy and Exploration Inc., USA, 1992
2. V. S. Vutukuri and K. Katsuyama, ***Introduction to Rock Mechanics,*** Industrial Publishing & Consulting Inc., Tokyo, 1994
3. B. H. G. Brady and E. T. Brown, ***Rock Mechanics for Underground Mining***, George Allen and Unwin Ltd., 1992
4. J. C. Jeager and N. G. W. Cook, ***Fundamentals of Rock Mechanics***, Chapman and Hall, 1979
5. J. A. Franklin & M. B. Dusseault, ***Rock Engineering Applications***, Mc Graw Hill, 1991.

MN 324	STRATA CONTROL TECHNOLOGY	4 credits [3-1-0]

Geomining conditions: Geological factors contributing to strata control problems in mines, Geomechanics classification of rocks; Safety status: Status of safety in coal mines vis-à-vis strata control problems, Assessing the risk from the hazards of roof & side falls; Design of support system: Design of support system for development and depillaring workings, Design of support system for long wall workings, Application of modeling techniques to strata control problems; Strata behaviour studies: Instrumentation for evaluation of strata condition in coal mines, Strata control techniques and its application to coal mining industry, Case studies on geotechnical instrumentation and strata control in coal mines, Demonstration of geotechnical instrumentation and computer softwares; Organization of strata control cell: strata control cell in mines, Training needs of the first line supervisors for effective implementation of the latest strata control technologies.

Essential Reading:
1. M. L. Jeremic, ***Strata Mechanics In Coal Mining***, A A Balkema, Rotterdam, Taylor and Francis, 1985, 566p
2. T., Bieniawski Ziti, ***Strata Control in Mineral Engineering***, New York: John Wiley & Sons, 1 Feb 1987.

Supplementary Reading:
1. T. N. Singh, ***Underground winning of Coal***, Oxford and IBH New Delhi, 1992
2. B. H. G. Brady and E. T. Brown, ***Rock Mechanics for Underground Mining***, George Allen and Unwin Ltd., 1992
3. J. A. Hudson, ***Comprehensive Rock Engineering***, Pergamon Press, UK, 2000
4. Z. T. Bieniawski ***Engineering Rock Mass Classifications***. Wiley, New York. 251, 1989.
5. S S Peng and H S Chiang, ***Longwall mining***, Wiley; New York, 708p.

MN 325	GROUND CONTROL INSTRUMENTATION	4 credits [3-1-0]

Deformation and Strain Measuring Instruments: Convergence meters, convergence recorders, tape extensometers, bore hole deformation, gauge, multipoint borehole extensometers and bore hole camera; Load and Pressure Measuring Instruments: Load cells, pressure measuring instruments – stress capsules, stress meters, borehole pressure, cells and flat jacks. Strain gauges and transducers, readout units, sensors, transmitters and data acquisition systems; Testing Equipment: UTM, MTS and acoustic emission equipment. Rock bolt pull tester, Monitoring and interpretation of the data; Applications: Mining Engineering applications: Instrumentation in underground mines and opencast mines; Civil Engineering applications; Instrumentation in Hydro electric projects and Tunnels, case studies.

Essential Reading:
1. J. A. Hudson, ***Comprehensive Rock Engineering***, Pergamon Press, UK, 2000
2. M. L. Jeremic, ***Strata Mechanics in coal mining***, A A Balkema, Rotterdam, Taylor and Francis, 1985,

Supplementary Reading:

1. Z. T. Bieniawski, ***Strata Control in Mineral Engineering***, New York: John Wiley & Sons, 1987.
2. B. H. G. Brady and E. T. Brown, ***Rock Mechanics for Underground Mining***, George Allen and Unwin Ltd., 1992
3. Z. T. Bieniawski, ***Engineering Rock Mass Classifications***. Wiley, New York, 1989

MN 330	MINE VENTILATION	4 credits [3-1-0]

Composition of mine air, Mine gases: properties, origin, occurrence, physiological effects, detection, monitoring and control, Methane layering, Degasification of coal seams. Production, assessment, physiological effects and control of mine dusts; Thermal environment and psychrometry: Sources of heat load sources in mines, Effect of heat and humidity on miners. Psychrometry, Cooling power of mine air, Methods of improving of cooling power of mine air, Air Conditioning - basic vapour cycle; Mechanics of air flow through mine openings, Resistance of airways, Equivalent orifice, distribution of air current, control devices in ventilation systems, Natural ventilation: Calculation of NVP, Thermodynamic aspects, Artificial aids to natural ventilation; Mechanical ventilation: Principal types of mine fans, Installation, operation, characteristics and selection of mine fans, Fan testing and Out put Control, Fan laws and fan drives, Evasees, Diffusers, Booster fans, Auxiliary ventilation. Reversal of air currents and controlled recirculation; Ventilation Survey: Quantity and Pressure survey; Planning and Design of Ventilation Systems: mine ventilation design criteria and ventilation design factors, ventilation standards, Ascensional, descensional, homotropal, antitropal, central and boundary ventilations systems, Ventilation layouts for coal and metal mining, Network analysis : Hardy-Cross method, Computer application in mine ventilation.

Essential Reading:

1. M. J. McPherson, ***Subsurface Ventilation and Environmental Engineering***, Chapman & Hall, 1993
2. G. B. Mishra, ***Mine Environment and Ventilation***, Oxford University Press, Fifth Impression, 1993

Supplementary Reading:

1. H. L. Hartman, ***Mine Ventilation and Air Conditioning***, John Wiley, Paperback edition, 1989.
2. H. L. Hartman, J. M. Mutmansky, R. V. Ramani and Y. J. Wang, ***Mine Ventilation And Air Conditioning***, Wiley-interscience, 3rd Edition, 1997
3. S. P. Banerjee, ***Mine Ventilation***, Lovely Prakashan, 1st Edition, 2003
4. M. A. Ramlu, ***Mine Disaster and Mine Rescue***, Oxford & IBH, 1991

MN 331	Solid Fuel Technology	3 credits [3-0-0]

Introduction: Processes of formation of coal, Theories of origin of coal, Eras of coal formation, Indian Coalfields and its subsidiaries: Occurrence and distribution, coal bearing formations, coal type and rank variation, Characteristics of major coalfields, Coal production from different sectors.; Coal petrography: Macro and micro lithotypes, Composition of macerals, application of coal petrography, Mineral matter in coal: Origin and chemical composition, Impact of mineral matter in coal process industry; Coal properties and their evaluation: proximate and ultimate analysis, calorific value, crossing and ignition point temperature, plastic properties(free swelling index, Caking index, Gray King Low Temperature Assay, Roga index, plastometry, dilatometry), physical properties like specific gravity, hard groove grindability index, heat of wetting, Crossing point temperature of coal, Behaviour of coal at elevated temperatures and products of thermal decomposition, Classification of coal - International and Indian classification, grading of Indian coals; Coal Washing: Principles, objectives, coal preparation, washability characteristics; Selection, testing, storage and utilization of coking and non-coking coal, Use of coal by different industries

Essential Reading:

1. S. Sarkar, ***Fuels and Combustion***, Orient Longman Private Ltd., 2nd edition, 1990.
2. O. P. Gupta, ***Elements of Fuels, Furnaces and Refractories,*** Khanna Publication, 3rd Edition, 1996.

Supplementary Reading:

1. M. A. Elliot, ***Chemistry of Coal Utilization***, Wiley, 1981.
2. N. Berkowitz, ***An Introduction to Coal Technology,*** Elsevier, 1993.
3. D. Chandra, R. M. Singh, and M. P. Singh, ***Text Book of Coal,*** Tara Book Agency, 2000.
4. G. G. Sarkar, ***An Introduction to Coal Preparation Practice,*** Oxford and IBH, 1986.
5. S. P. Mathur, ***Mine Planning for Coal,*** M. G. Consultants, Bilaspur, 1993.

MN 332	Remote sensing and ITS APPLICATION	4 credits [3-1-0]

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.

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

MN 336	SOLID FuelS AND CLEAN COAL Technology	3 credits [3-0-0]

Introduction: Processes of formation of coal, Theories of origin of coal, Eras of coal formation, Indian Coalfields and its subsidiaries: Occurrence and distribution, coal bearing formations, coal type and rank variation, Characteristics of major coalfields, Coal production from different sectors.; Coal petrography: Macro and micro lithotypes, Composition of macerals, application of coal petrography, Mineral matter in coal: Origin and chemical composition, Impact of mineral matter in coal process industry; Coal properties and their evaluation: proximate and ultimate analysis, calorific value, crossing and ignition point temperature, plastic properties(free swelling index, Caking index, Gray King Low Temperature Assay, Roga index, plastometry, dilatometry), physical properties like specific gravity, hard groove grindability index, heat of wetting, Crossing point temperature of coal, Behaviour of coal at elevated temperatures and products of thermal decomposition; Classification of coal: International and Indian classification, grading of Indian coals; Coal Washing: Principles, objectives, coal preparation, washability characteristics; Selection, testing, storage and utilization of coking and non-coking coal, Use of coal by different industries; Clean Coal Technology: Introduction, Pre-combuction, Combustion and Post combustion clean coal technology, Conversion

Essential Reading:

1. S. Sarkar, ***Fuels and Combustion***, Orient Longman Private Ltd., 2nd edition, 1990
2. O. P. Gupta, ***Elements of Fuels, Furnaces and Refractories***, Khanna Publication, 3rd Edition, 1996

Supplementary Reading:

1. M. A. Elliot (ed.), ***Chemistry of Coal Utilization***, Wiley, 1981
2. N. Berkowitz, ***An Introduction to Coal Technology***, Elsevier, 1993
3. D. Chandra, R. M. Singh and M. P. Singh, ***Text Book of Coal***, Tara Book Agency, 2000
4. G. G. Sarkar, ***An Introduction to Coal Preparation Practice***, Oxford and IBH, 1986
5. S. P. Mathur, ***Mine Planning for Coal***, M. G. Consultants, Bilaspur, 1993

MN 370	MINE VENTILATION LABORATORY	2 credits [0-0-3]

Determination of Relative Humidity of Mine air with Fixed/stationary Hygrometer, and Whirling Hygrometer; Determination of Relative Humidity of air using Assman Psychrometer; Determination of cooling power of air using Kata Thermometer; Determination of CO% by MSA CO detector; Determination of percentage of CO and CO_2 by Drager Multi Gas Detector (Model 21/31); Determination of Methane % by MSA D-6 Methanometer; Study of the construction and working of Flame Safety Lamp (VELOX GL-50, GL-60 and MSA type); Gas Testing by Flame Safety Lamp in a Gas Testing Chamber; Measurement of Air Velocity by (i) Vane Anemometer (ii) Electric Analog Velometer; Study of Pitot Static Tube & measuring of Air Velocity in a ventilation duct in combination with an Inclined Manometer; Measurement of dust concentration by (i) Gravimetric Dust Sampler, (II). Personal Dust Sampler; Measurement of dust concentration by High Volume Sampler; Measurement of Noise Level by Integrating Sound Level Meter (CEL-283)

MN 371	ROCK MECHANICS LAB	2 credits [0-0-3]

Preparation of Rock Specimens for various testing purposes; Study of Compressive Testing Machine; Determination of Protodyakonov Strength Index; Determination of Impact Strength Index; Determination of the Uni-axial Compressive Strength of rock materials; To Determine the Tensile Strength of a rock specimen by an Indirect Method (Brazilian Test); Determination of Point Load Strength Index; Determination of Shear Strength by Direct Shear Test; Determination of

Modulus of Elasticity and Poission's ratio of rock samples; Determination of Slake Durability Index of rock samples; Determination of Slake Durability Index of coal samples; Determination of Permeability of rock; Determination of C – ϕ by using Tri-axial Cell Unit; Determination of Index Parameter using Schmidth Hammer

MN 372 COMPUTER APPLICATION IN MINING LABORATORY 2 credits [0-0-3]

Ore body modeling using SURPAC; Application of SURPAC for mine scheduling; Study of stress distribution around single opening using FLAC –2D; Study of stress distribution around single opening using FLAC –3D; Study of stress distribution around single opening using UDEC; Study of stress distribution around circular opening; Stress distribution around rectangular opening; Study of stress distribution around multiple openings; Study of deformation around circular opening; Study of deformation around single opening using FLAC –2D; Study of deformation around single opening using UDEC; Study of deformation around multiple openings

MN 373 MINERAL PROCESSING TECHNOLOGY LABORATORY 2 credits [0-0-3]

Particle size analysis of different rocks and minerals; Study of Jaw Crusher and determination of its Actual Capacity; Finding out Reduction Ratio using jaw crusher; Verification of Rettinger's Law using jaw crusher; Study of Hammer Mill and determination of its Actual Capacity; Finding out Reduction Ratio using Hammer Mill; Verification of Kick's' Law using Hammer Mill; Study of Rod Mill and determination of its Actual Capacity; Study of the effect of Ball Load and time on Grinding using Ball Mill; Study of Vibrating Screen and Determination of its Effectiveness; Study of Magnetic Separator and Determination of its Efficiency; Study of Baum Jig and Determination of its Efficiency.

MN 374 GEOMECHANICS LABORATORY 2 credits [0-0-3]

Study of Universal Testing Machine; Evaluation of ground vibration using Blastmate; Determination of Explosive Strength by V. O. D. Monitor; Determination of rock hardness by Hardness Tester; Determination of Rock In-situ Stress by Flat Jack Unit; Determination of the relation between the moisture content and the dry density of the loose rock materials using light compaction; Study of Bore hole stress meter; To study the Permeability characteristics of coal specimens; Determination of crushing strength of rock, slag, aggregate gravel by using LOS Abrasion Testing Machine; Determination of Aggregate impact value of rock/ concrete by using Aggregate Impact Test Apparatus; Determination of Impact Strength with Pendulum Impact Tester; Introduction to a few numerical modeling software's etc.

MN 375 MATERIAL HANDLING SYSTEMS LABORATORY 2 credits [0-0-3]

Study of bi-cable aerial rope-way; Study of headgear and pulleys; Study of cage & skip; Study of different types of keps; Study of scraper chain conveyor; Study of belt conveyor; Study of gate end box; Study of king detaching safety hook; Study of mechanism of shaft sinking; Study of winding shaft; Study of safety devices in haulage; Study of cage attachment to winding rope

MN 376 MODEL PREPARATION LABORATORY 2 credits [0-0-3]

Preparation of surface mining models; Preparation of underground coal mining models; Preparation of underground metal mining models; Preparation of underground mine ventilation models; Preparation of underground transport models; Preparation of underground excavation models; Preparation of underground man riding models; Preparation of underground support models; Preparation of opencast bench models; Preparation of reclamation models; Preparation of models on blasting in opencast mines; Preparation of models on blasting in underground mines

MN 377 SOLID FUEL TECHNOLOGY LABORATORY 2 credits [0-0-3]

Determination of Moisture Content of Coal; Determination of volatile matter content of coal sample; Determination of ash content of coal sample; Determination of the true and bulk density of supplied coal sample; Determination of caking index of coal; Determination of free swelling index of coal; Determination of washability characteristics of coal sample by float and sink analysis; Determination of calorific value of coal using bomb calorimeter; Determination of Hardgroove Grindability index of coal; Determination of Crossing point temperature of coal; Determination of Critical Air Blast value coal; Assessment of spontaneous heating susceptibility of coal using DTA.; Assessment of spontaneous heating susceptibility of coal using wet oxidation potential analysis.

MN 400 MINE PLANNING 4 credits [3-1-0]

Principles of Mine Planning: Mining industry in comparison to other industries, Planning for mineral policy, Plans to be maintained in the mineral industry, Stages of planning of new mines, requirements of planning, Master Plan, Feasibility Report, Detailed project report; Technical considerations in Planning: Selection of method of mining, opening up of open cast mines and underground mines, development of open cast mines and underground mines, Division of mine lease area into mining Units, location of entries, Surface layouts, pit bottom layout, Ventilation planning; Planning of mine workings and systems: infrastructure planning, production planning, Mineral handling plant, optimal planning, Planning of special methods of Coal and metal mines, Placer Mining, Sea bed Mining; Socio-Economic considerations: Social aspects, Environment Management Plan, estimation of mining costs and profits, Restructuring planning, Issues and challenges of Mine planning in the future, Mine Closure plan; Computer applications in mine planning & design.

Essential Reading:

1. S. P. Mathur, ***Mine Planning for Coal,*** M. G. Consultants, Bilaspur, 1993
2. J. Bhattacharya, ***Principles of Mine Planning***, Allied Publishers Pvt Limited, New Delhi, 2003

Supplementary Reading:

1. W. Hustrulid and M. Kuchta, ***Open Pit Mine Planning and Design***, A. A. Balkema Rotterdam, 1995
2. B. M. Vorobjev and R. T. Desmukh, ***Advanced Coal Mining Vol-II***, Asia Publishing houseBombay, revised edition, 1966
3. PWJ Van Rensbarg***, Planning Open-pit mines,*** AA Balkema Cape Town, 1970
4. A. A. Myasnikov, ***Principle of Coal Mine Ventilation Planning***, N. T. I. S., 1981.
5. R D Singh, ***Principles and Practices of Modern Coal Mining***, New age International Pvt limited Publishers, New Delhi, 1997.
6. H. L. Hartmanetal, ***SME Mining Engineering Handbook, Vol. I & II***, SME, USA, 1992.

MN 410 Tunneling 4 credits [3-1-0]

Design of tunnels: Rock mass classification, stability analysis of tunnels, elastic and plastic deformation; Ground control: stress conditions, behavior of ground, Geomechanics instrumentation, design of supports; Equipments, Tunnel Boring Machines, ventilation, tunnel economics.

Essential Reading:

1. Richard E Bullock, ***Tunneling and Underground Construction Techniques***, SME Publication, 2002
2. Stack Barbara, ***Hand book of Mining & Tunneling Machinery,*** John Wiley and Sons.

Supplementary Reading:

1. R. V. Proctor, ***Rock Tunneling with Steel Supports***
2. F. O. Franciss, ***Weak rock tunneling***, Taylor and Francis, 1994
3. J. Johansen, ***Modern trends in tunneling and blast design***, Taylor and Francis, 2000
4. F. D. Davidson, ***Tunneling and Transport***, Elsevier APPLIED Science, 1987
5. Bieniawski Z. T, ***Rock Mechanics Design in Mining & Tunneling***
6. Edi Bickel J. O., T. R. Kuesel & E. H. King, ***Tunnel Engineering Handbook***

MN 411 ADVANCED SURFACE MINING 4 credits [3-1-0]

Introduction, Indian context of advance surface mines, Advancement in mine unit operation.; Planning of surface mines viz, Procedural steps of planning, Ore body description, Mining Systems, Ultimate pit configuration. Design of surface mines, Feasibility Report & Detailed Project Report, Modern surface mining equipments.; Legislations related to surface mining, Mine Closure Planning.

Essential Reading:

1. R. T. Desmukh, ***Opencast Mining***, Lovely prakashan Dhanbad, 1st ed, 1990.
2. S. K. Das, ***Surface Mining Technology***, Lovely prakashan Dhanbad, 1st ed, 1994.

Supplementary Reading:

1. G. B. Mishra, ***Surface Mining,*** Lovely Prakashan Dhanbad, 1st ed, 1971.
2. E. Hoek and J. Bray, ***Rock Slope Engineering***, 3rd Ed., Inst. Of Mining and Metallurgy, London, 1980
3. W. Hustrulid and M. Kuchta, ***Open pit mine planning and Design***, Vol - I, A. A. Balkema Rotterdam, 1st ed, 1995.
4. B. Cummins Arthur, ***SME Mining Engineers Hand Book***, American Institute of Mining, Metallurgical and Petroleum Engineers New York, 1973

MN 412 MINING OF DEEP SEATED DEPOSITS 4 credits [3-1-0]

Exploration: Modern Exploration Techniques to Identify the Complex Coal Deposits; Classification: Classification of Coal Deposits Lying under Typical Geo-mining Conditions; Challenges: Challenges to improve Production and Productivity from Deep Seated Deposits, Challenges in Liquidation of Locked-up Pillars; Experimental trials: Innovative Technologies for Stability Analysis, Design and Development of Deep Seated Deposits; Modern techniques: Application of Numerical Modeling Techniques to Control Ground Problems of Complex Deposits, Use of Modern Instruments for Strata Control of deep seated deposits, In-situ Gasification and Mineral Biotechnology for Complex Coal Deposits.

Essential Reading:

1. R. D. Singh, ***Principles & Practices of Modern Coal Mining***, New age international New Delhi, 1997
2. T. N. Singh, ***Underground winning of Coal***, Oxford and IBH New Delhi, 1992

Supplementary Reading:

1. S. S. Peng and H S Chiang, ***Longwall mining***, Wiley; New York, 708p.
2. S. K. Das, ***Modern Coal Mining Technology,*** Lovely prakashan Dhanbad, 1992
3. D. Prasad and S Rakesh, ***Legislation in Indian Mines-A critical Appraisal***, Niskam Press, New Delhi, 1883p.
4. S. P. Mathur, ***Coal Mining in India***, M. S. Enterprises Bilaspur, 1999

MN 413 ADVANCED COAL MINING 4 credits [3-1-0]

Extraction of thick seams: Problems and issues, recent experimental trials Chirimiri caving Method, Blasting Gallery Method, Integral Caving method, Sublevel caving method, Hydraulic Mining, Shield Mining; Extraction underneath surface features: Non-Effective width (NEW), Back filling methods, Wide stall mining.; Extraction of multiple seams: Problems and issues, recent experimental trials, Parting failures and control, design of workings; Extraction of locked up pillars: Status of Bord and pillar mining in India, techniques of extraction and future requirements; Support systems: Strata behavior at greater depths, problems of strata control in high horizontal stress fields, design of support system.

Essential Reading:

1. R. D. Singh, ***Principles & Practices of Modern Coal Mining***, New age international New Delhi, 1997
2. T. N. Singh, ***Underground winning of Coal***, Oxford and IBH New Delhi, 1992

Supplementary Reading:

1. D. J. Deshmukh, ***Elements of Mining Technology***, Vol - I, EMDEE publishers Ranchi, Revised edition, 2000.
2. S. K. Das, ***Modern Coal Mining Technology,*** Lovely prakashan Dhanbad, 1992
3. S. P. Mathur, ***Coal Mining in India***, M. S. Enterprises Bilaspur, 1999

MN 414 ROCK MECHANICS APPLICATION TO ENVIRONMENTAL PROBLEMS 3 credits [3-0-0]

Classification of Rock for specific engineering purposes- Underground, Surface, etc. Mechanical properties of discontinues rocks – Planes of discontinuity in rocks, characteristics and orientation of Joints; Measurement of rock mass deformability- Insitu Testing; Applications - Opencast mining and slope stability, Underground mining and excavation, - massive rocks, layered rocks, weak rocks; Application to waste disposal and underground storage, application to earthquakes.

Essential Reading:

1. J. A. Franklin and M. B. Dusseault, ***Rock Engineering***, McGraw-Hill, Inc., 1991
2. R. E. Goodman, ***Introduction to Rock Mechanics***, John Wiley and Sons, 1980

Supplementary Reading:

1. L. Hartman et al, ***Mining Engineering Handbook***, Society for Mining, Metallurgy and Exploration Inc., USA, 1992
2. V. S. Vutukuri and K. Katsuyama, ***Introduction to Rock Mechanics***, Industrial Publishing & Consulting Inc., Tokyo, 1994
3. B. H. G. Brady and E. T. Brown, ***Rock Mechanics for Underground Mining***, George Allen and Unwin Ltd., 1992
4. J. C. Jeager and N. G. W. Cook, ***Fundamentals of Rock Mechanics***, Chapman and Hall, 1979
5. E. Hoek and J. Bray, ***Rock Slope Engineering***, 3rd Ed., Inst. Of Mining and Metallurgy, London, 1980
6. J. A. Hudson, ***Comprehensive Rock Engineering***, Pergamon Press, UK, 2000
7. J. A. Franklin and M. B. Dusseault***, Rock Engineering Applications,*** McGraw-Hill, Inc., 1991.

MN 415 ADVANCED METALIFERROUS MINING 4 credits [3-1-0]

Methods: Techno-economic analysis on choice of stoping methods, high productivity methods: blasthole stoping, vertical retreat method of mining, block caving, raise stoping, underground bench blasting, stope design and production planning in the various methods of stopping; Special underground excavations: shaft pockets, ore bins, ore transfer, ramp, decline, step mining methods, stope fills: preparation, transportation and filling operation, stope design and production planning, methods of pillar extraction, solution mining: in situ leaching, underground retorting, under-sea mining, introduction to novel mining methods, Special underground excavation and system of supports; Pillar extraction: methods of pillar extraction, salt, potash and sulphur mining- their special problems.

Essential Reading:

1. Y. P. Chacharkar, ***A study of Metalliferous Mining Methods***, Lovely prakshan Dhanbad, 1994
2. K. S. Stout, ***Mining Methods and Equipment***, McGraw hill New York, 1980

Supplementary Reading:

1. B. C. Arthur, ***SME Mining Engineers Hand Book***, American Institute of Mining, Metallurgical and Petroleum Engineers New York, 1973.
2. D. J. Deshmukh, ***Elements of Mining Technology***, Vol - II, Central Techno Publications, Nagpur, 2001
3. ***Metal Mines Regulations-1961***, Lovely Prakashan

MN 421	ROCK SLOPE TECHNOLOGY	3 credits [3-0-0]

Types and Mechanics of Slope Failure: Site investigation for slope assessment. Geological appraisal of slope behaviour, Types of slope failure, falls, slides and flows. Mechanics of slope failure; Factors Affecting Slope Stability: Geological factors, slope geometry, ground water, equipment loading, dynamic loading and effect of time; Slope Stability Analysis: Failure mechanisms, shear strength of soil and rock masses. Influence of groundwater. Evaluation of stability and risk. Earth dams, stability analysis, numerical models, empirical models; slope Mass Rating System, Slope instrumentation. Remedial measures; Design of Waste Dumps and Tailings Dams: stability analysis of opencast high walls and benches, overburden dumps, case studies.

Essential Reading:

1. R. N. Chowdury, ***Slope Analysis***, Elseveir, 1978
2. E. Hoek and J. Bray, ***Rock Slope Engineering,*** The Inst. of Mining & Metallurgy, London, pp. 358, 1981

Supplementary Reading:

1. B. F. Walker and R. Fell, ***Soil slope instability and stabilisation***, A A Balkema, 1987
2. E. N. Bromhead, ***Stability of slopes***, Wiley, London
3. M. L. Jeremic, ***Strata Mechanics In Coal Mining***, A A Balkema, Rotterdam, Taylor and Francis, 1985, 566p
4. J. A. Hudson, ***Comprehensive Rock Engineering***, Pergamon Press, UK, 2000
5. Z. T. Bieniawski, ***Engineering Rock Mass Classifications.*** Wiley, New York, 1989.

MN 431	MINE ENVIRONMENTAL ENGINEERING	4 credits [3-1-0]

Spontaneous Heating and Mine Fires: Spontaneous Heating : Causes, incubation period, detection, remedial measures. Mine Fires -Classification, causes, preventive measures, dealing with mine fires – direct and indirect methods, reopening of scaled off areas.; Explosion: Fire-damp Explosion - Limits of inflammability of methane, causes of ignition, nature of fire damp explosion, propagation and prevention. Coal-dust Explosion - Index of inflammability, factors affecting explosibility of coal dust, causes and safeguards. Propagation of coal dust explosions, Investigation after an explosion.; Mine Illumination: Its effects on safety, efficiency and health, Flame and electric safety lamps- their uses and lamp-room – lay out and organization, standards of illumination in mines, lighting from the mains, photometric illumination survey, Miners' diseases

Essential Reading:

1. M. A. Ramlu, ***Mine Disaster and Mine Rescue***, Oxford & IBH, New Delhi, 1991
2. S. C. Banerjee, ***Prevention and Combating Mine*** Fires, Oxford & IBH, New Delhi, 2000.
3. B. K. Kejriwal, ***Safety in Mines***, Lovely Prakashan, Dhanbad.

Supplementary Reading:

1. A. T. Donalad, ***The lighting of Underground Mines***, Trans Tech Switzerland, 1982
2. R. Mcadam and D. Davidson, ***Mine Rescue Work***, Oliver and Boyd, London, 2000

MN 433	ENVIRONMENTAL IMPACT ASSESSMENT	3 credits [3-0-0]

INTRODUCTION: Environmental Impact Assessment (EIA) – Environmental Impact Statement – EIA in Project Cycle – Legal and Regulatory aspects in India according to Ministry of Environment and Forests – Types and limitations of EIA – Cross sectoral issues and terms of reference in EIA –Participation of Public and Non-Governmental Organizations in environmental decision making; COMPONENTS AND METHODS: Components of EIA - Processes – screening – scoping - setting – analysis – mitigation. Matrices – Networks – Checklists – Connections and combinations of processes - Cost benefit analysis – Analysis of alternatives – Software packages for EIA – Expert systems in EIA; PREDICTION, ASSESSMENT OF IMPACTS AND REPORTING: Prediction tools for EIA – Mathematical modeling for impact prediction – Assessment of impacts – air – water – soil – noise – biological – socio-cultural environments – Cumulative Impact

Assessment – Documentation of EIA findings – planning – organization of information and visual display materials – Report preparation; ENVIRONMENTAL MANAGEMENT PLAN : Environmental Management Plan - preparation, implementation and review – Mitigation and Rehabilitation Plans – Policy and guidelines for planning and monitoring programmes – Post project audit – Ethical and Quality aspects of Environmental Impact Assessment; CASE STUDIES: Case studies related to the following sectors - Infrastructure - Mining – Industrial - Thermal Power - River valley and Hydroelectric - Nuclear Power.

Essential Reading:

1. D. P. Lawrence, ***Environmental Impact Assessment – Practical Solutions to recurrent Problems***, Wiley-Interscience, New Jersey. 2003
2. J. Petts, ***Handbook of Environmental Impact Assessment***, Vol., I and II, Blackwell Science London. 1999.
3. R. Therivel, J. Glasson & A. Chadwick, ***Introduction to Environmental Impact Assessment***, 3rd Edition, Routledge, 2005.

Supplementary Reading:

1. L. W. Canter, ***Environmental Impact Assessment***, McGraw-Hill, New York. 1996.
2. A. K. Biswas, and S. B. C. Agarwala, ***Environmental Impact Assessment for Developing Countries***, Butterworth Heinemann, London. 1994
3. The World Bank Group, ***Environmental Assessment Source Book Vol. I, II and III***. The World Bank, Washington. 1991.

MN 435	ECO-FRIENDLY MINING	4 credits [3-1-0]

Overview: Basic concept of eco-friendly mining. Selection of eco-friendly equipment and exploitation operations, Environmental Parameters: Water quality – physical, chemical, biological, criteria and standards. Classification andchemistry of major air pollutants. Soil chemistry – nature and importance of soil, soilproperties, soil amendments, Waste Management: Waste water management – sources characteristics, techniques of treatment. Acid minedrainage – occurrence, effects and treatment techniques. Solid waste management for minespoils, Mine Reclamation & Mine Closure: Mine Reclamation strategies, Principles, planning, financial provisions, implementation, standards for closure criteria, systems approach for mine closure and development of closure plan, Socio-economic Aspects of Mining.

Essential Reading:

1. H. S. Peavy, D. R. Rowe and G. Tchobanoglous, ***Environmental Engineering***, McGraw-Hill Publishing Co.; 7th Rev Ed edition, 2000.
2. C. J. Barrow, ***Environmental Management: Principles and Practice*** (Routledge Environmental Management Series) Routledge, 1st edition, 1999.

Supplementary Reading:

1. P. G. Hutchison, and R. D. Ellison, ***Mine Waste Management***, CRC Press, 1st edition, 1992
2. G. Burke, B. R. Singh and L. Theodore, ***Handbook of Environmental Management and Technology***, Wiley-Interscience, 2nd edition, 2000.
3. N. C Saxena, ***Mining Environment Management Manual***, Scientific Publishers (India), 2004
4. M. J. Hammer, ***Water and Wastewater Technology***, Prentice Hall, 6th edition, 2007.

MN 436	ENVIRONMENTAL POLLUTION AND CONTROL IN MINES	4 credits [3-1-0]

General: Environmental issues in Mineral Industry- National and Global, Environmental impacts of Mineral exploitation - in underground and opencast mining.; Land Environment: Subsidence, visual impacts, landscape pollution, land degradation, land reclamation, land use, landscape planning, ecology.; Societal Development: Socio-economic impacts, sustainable development, concept of carrying capacity based planning; Pollution: Water - Availability, quality, pollution and treatment, Liquid effluents: Quality, treatment and disposal. Solid Wastes - Generation, treatment and disposal, hazardous waste management and planning. Tailings disposal & treatment systems. Air: Pollution, monitoring and Control. Noise and Ground vibration - Causes, precautions, prevention and reduction.; Environmental Management Plan (EMP), Environmental Impact Statement (Environmental Impact Assessment (EIA), Environmental Legislation in India. Environmental Audit of Mining EIS) projects.

Essential Reading:

1. M. Sengupta, ***Environmental Impacts of Mining,*** Lewis Publishers, CRC Press, NY, 1993.
2. G. M. Masters, ***Introduction to Environmental Science & Engineering,*** PHI, 2004.
3. N. C, Saxena, G. Singh & R. Ghosh, ***Environmental Management in Mining Areas***, Scientific Publishers(I), Jodhpur, 2002.

Supplementary Reading:

1. B. B. Dhar and D. N. Thakur, ***Proceedings of the first World Mining Environment*** Congress, Taylor and Francis, 1996.
2. R. G. A. Boland, ***Environmental Management training***, Sterling publishers New Delhi, 1986.
3. D. P. Tripathy, ***Noise Pollution***, APH Publishers, New Delhi, 2009.

MN 438	Solid Waste Management	3 credits [3-0-0]

Classification & characterization of waste, collection, Handling of Industrial (Mining, Thermal, Chemical, Radioactive, Biomedical, etc.) and Domestic Waste, Utilisation of wastes,; Federal and State regulations on Waste Management, Recycling, Recovery and Reuse of Wastes, Optimisation of waste Disposal System.; Global Scenario in Waste Management.

Essential Reading:

1. M. L. Davis and W. A. Eornwell, ***Introduction to Environmental Engineering***, McGrow Hill Publishing Co, NY
2. G. N. Pandey & G. C. Carney, ***Environmental Engineering,*** 1st edn. Tata McGraw-Hill, New Delhi, India

Supplementary Reading:

1. ***Hazarding waste Rules***, 1989
2. James H. Saling, W Andson, Y. S Fertiman, ***Radioactive Waste Management***, Tayler & Francis Group 2nd edition

MN 441	MINE LEGISLATION AND SAFETY ENGINEERING	4 credits [3-1-0]

Mine Legislation: General principles of Mining Law, Principal Provisions of Mines Act, Mines and Minerals (Regulation and Development) Act, Mineral Concession Rules, Mines Rules 1955, Electricity Rules, Industrial Disputes Act. 1947, Mine Rescue Rules.; Mine Safety : Accidents- Their causes and prevention, accident statistics, rates of accidents, relation between accidents and efficiency, accident reports, cost of accidents.; Safety risk assessment and management, Safety Audit, Occupational health and safety in mines. Mine safety management systems, Safety education and training.

Essential Reading:

1. B. K. Kejriwal, ***Safety in Mines***, Lovely Prakshan Dhanbad, 2002
2. Rakesh and S. D. Prasad, ***Legislation in Indian Mines: A critical appraisal, Vol- I & II***, Mrs Asha Lata Varnasi, 5th ed, 1990

Supplementary Reading:

1. V. K. Malhotra, ***Mineral Concession Rules-1960***, Malhotra Bros., Patna, Supplementary Ed., 1993
2. A. K. Ghosh, S. K. Ray and A. K. Patra, ***Proceeding of the National Seminar on Policies, Statutes & Legislation in Mines***, CIMFR, Dhanbad, India, 2008
3. R. S. Rao, ***Law of Mines and Minerals***, S. N. Hussainy (Revised), Asia Law House, 8th Eds, 1996.

MN 442	MINE FIRES AND SPONTANEOUS HEATING	4 credits [3-1-0]

Mine Fires: Accidental Fires – it causes and precautions, Survey of various causes of mine fires with statistical data of Indian mines. Physical and chemical factors governing proneness to fire in coal and metaliferrous mines. Various methods adopted to combat fires and their advantages and disadvantages. Advances in fire fighting techniques and equipments, rescue operations in fire-zones.; Spontaneous Heating: Various causes of spontaneous heating and statistical data in Indian mines, Theories of spontaneous heating of coal, Geological, Mining and Seam factors governing spontaneous heating. Intrinsic and extrinsic properties of various substances e.g. -porosity, permeability, pore distribution Moisture etc. on spontaneous heating; Different experimental techniques including modern techniques like DTA/TGA and DSC to measure liability indices and relative proneness of spontaneous heating; use of clean coal technology and neural network to detect spontaneous tendency, effect of microwave treatment and pyrite removal on spontaneous heating; Sampling of mine atmosphere, Interpretation of mine air analyzing data, fire risk management, environmental indices, Different methods to seal off fire areas; Reopening of sealed off fire areas; Early detection of spontaneous heating in mines and stacks, recent trends to eliminate recurrence of spontaneous heating.

Essential Reading:

1. S. C. Banerjee, ***Coal and Mine Fire***, Oxford and IBH, 2004
2. Albert Edward, McGraw hill publishing House, USA. 2008.

Supplementary Reading:

1. L. C. Kaku, ***Fires in Coal Mines***, Oriental Publishers, 2nd Edition, 1985

MN 451	MINE MANAGEMENT	4 credits [3-1-0]

Introduction: Evolution of management; theory and practice; principles of scientific management; elements of management function; planning; organization and control; structure and design of organization for mining enterprises. Personal Management: Selection; training and development of human resources for mining enterprises; leadership; study of traditional leader hehaviour; autocratic; democratic and Laissez-Faire behaviours; Production

Management: Determination of norms and standards of operations by work study; analysis of mine capacities and capability; production planning; scheduling and control; short term and long term planning; productivity; concepts and measurements; application of Ergonomics in mine operation. Financial Management: Capital budgeting; technicques for mining project; project evaluation; payback period and IRR; methods of cost analysis and cost control; breakeven charts; working capital management. Materials Management: ABC Analysis, Inventory Management; Purchase policies, P and Q system, inventory control, Review period, lead time. Behavioural Sciences for Management: Conflict management; conflict in organization; sources of conflict; dealing with conflict; organizing for conflict resolution; conflict and growth; Individual motivation; two way personal communication. Maintenance Management: Definition, Classifying Reliability, Types of Maintenance; Break-down, scheduled, preventive, predictive, protective and lean maintenance. Marketing Management: Strategic planning & marketing management processes, marketing environment, marketing information systems, market management and forecasting; New product development processes.

Essential Reading:

1. I M Pandey***, Financial Management,*** Vikash Publishing House Pvt. Ltd., New Delhi
2. P. Gopalakrishnan & M. Sundaresam, ***Materials Management- An Integrate Approach,*** Prentice Hall India Pvt. Ltd., New Delhi
3. SC Saksena, ***Business Administration and Management***, Sahitya Bhawan, Agra.

Supplementary Reading:

1. P. Kstler, ***Marketing Management***, Prentice Hall India Pvt. Ltd. New Delhi
2. M. Telsang, ***Industrial Engineering and Production Management***, S. Chand & Co. Ltd., New Delhi
3. Lee & Dobbler, ***Purchasing and Materials Management,*** Tata Mc-Grand Hill Publishing Co. Ltd. New Delhi

MN 471 MINE ENVIRONMENTAL ENGINEERING LABORATORY 2 credits [0-0-3]

Study of MSA type Gas mask (Model: “SW”, Air purifying filter), (i) Filter type apparatus and (ii) Self Rescuer; Assessing spontaneous heating susceptibility of coal using DTA / wet oxidation apparatus; Study of Self Contained Breathing Apparatus. (i) Drager BG-174, (ii) By Travox-120; Study of Drager Pulmotor (Model: PT-60); Estimation of SPM concentration in air using high volume samplers; Study the construction and working of Explosion Proof Fire Stoppings; Determination of susceptibility of coal by chemical method or by puff temperature method; Determination of water quality parameters using water analyser kit; Determination of flammability temperature of coal by using inflammability index apparatus; Determination of nutrient status in soil using soil test kit; Measurement of Noise Level by Integrated Sound Level Meter (Model: CEL-283EX) and B & K sound level meter; Measurement of Lux by Light Meter

MN 472 MINE PLANNING AND DESIGN LABORATORY 2 credits [0-0-3]

Preparation of data base for mine evaluation; Create a geological data base and import all data files; Performing data compositing and statistical analysis; Create digital terrain model and surface contouring; Create section and digitization of individual sections; Create solid model using sections; Perform volume and area calculation of solid model, Union and intersection of different sections; Create block model; estimation of block models using inverse distance and polygonal method; Performing variogram analysis, fitting variogram, checking anisotropy; Intersection of block model and solid model; resource evaluation using ordinary kriging technique; Blast design using SURPAC software; Mine design using SURPAC software; Ultimate pit limit calculation; Determination of Grade tonnage curve and study the conditional biased in estimation

MN 473 SIMULATION AND MODELING OF MINING SYSTEMS LABORATORY 2 credits [0-0-3]

Simulation of underground openings-2D continuum models; Simulation of underground openings-3D continuum models; Simulation of underground openings- discontinuum models; Study of stability of underground opening – Mohr-Coulomb model; Study of stability of underground opening – Hoek-Brown model; Simulation of opencast workings; Study of stability of slopes – 2D continuum models; Study of stability of slopes – 3D continuum models; Study of stability of slopes – 2D discontinuum models; Design of supports for underground openings; Simulation of thick seam workings; Simulation of multiple seam workk

Curricula and Syllabi

Bachelor of Architecture (B.Arch)

2014-15 onwards

Department of Planning and Architecture
National Institute of Technology Rourkela
May 2014

DETAILED SYLLABI OF COURSES

Semester: 1

PA 111	Architectural Design – I	2 Credits (0-0-3)

Pre-requisites: NIL

Elementary forms, envelopes; exploration of relationship between form and space; understanding aesthetics with 2D and 3D forms; principles of design; study of lines, colour, texture, volume of objects with respect to contrast, harmony, balance, proportion; techniques of graphic expression to represent design ideas; appraisal of spatial, volumetric implications due to transformation of forms and spaces; 2D and 3D compositions, signage design, sculpture, thematic murals, etc.

Essential Reading:

D. K. Ching, ***From, Space and Order,*** Wiley

Supplementary Reading:

Von Meiss Pieree, ***Elements of Architecture***, Taylor and Francis

PA 121	Architectural Graphics – I	2 Credits (0-0-3)

Pre-requisites: NIL

Introduction to IS code of engineering drawing (dimensioning, labelling, sheet formatting); concept of scale; curves and conic sections (ogee curves, parabola, ellipse, hyperbola, cycloid, trochoid, involutes); projection of points; projection of lines (traces and true lengths); projection of planes and solids (cube, prism, pyramid, cylinder, sphere, cones); projection of auxiliary planes;

Essential Reading:

L. Warren J., D. Jon M., ***Fundamentals of Engineering Drawing – with an introduction to interactive computer graphics for design and production***, Prentice Hall

Supplementary Reading:

N. D. Bhatt, ***Engineering Drawing*,** Charotar Publishing House Pvt. Ltd.

PA 161	Principle of Architectural Design	3 Credits (3-0-0)

Pre-requisites: NIL

Architecture as a profession and role of an architect- Contribution towards culture and the society, the building process and the Architect’s role: How projects get built, need, site, financing, design and design approvals, Architectural services rendered by an architects and disciplines needed to learn by him/her

The structure of Architectural Education- Curricular content, Design, The Design Studio, History and Theory, Technology, Structures, Materials and Methods of Construction, Environmental Controls, Computer aided Design, Management, Electives.
Design Elements- Understanding Architectural Aesthetics - Exercises to understand the visual properties of two dimensional forms of both geometric and non-geometric surfaces. Basic design elements and their incorporation in visual art and architecture such Line and Shape, Color and Texture, Form and Size, Value, Light.
Design Principles- Principles such as Balance, Symmetrical, Asymmetrical, Proportion and Scale, Studies of Principles of Organization of Form & Space, Principles of three-dimensional Compositions.
Module and its application in design- Types of Common Grids – Orthogonal and Radial, Brief Introduction to History of Modular Construction in Architecture, (Industrial Revolution and Pre-fabrication of Iron, Steel, Glass and Concrete units), "Building as Machine" concept of Corbusier and Le Modular.
Factors influencing architecture of a region - Climate, material, technology and socio-cultural forces;
Defining and Conceptualizing Architecture - Different concept in the field through time, Concepts and philosophy of some leading architects; Introduction to few architectural projects (India and Global), Development of Architecture over ages

Essential Reading:

1. Francis D.K. Ching, ***Architecture Form Space and Order***, 3rd Edition, Wiley

Supplementary Reading:

1. Roger K. Lewis, ***Architect: A Candid Guide to the Profession***,
2. Leland M. Roth, ***Understanding Architecture: Its Elements, History, and Meaning***, Westview Press Place publication.

PA 171	**History of Architecture - I**	**3 Credits (3-0-0)**

Pre-requisites: NIL

Mesopotamian architecture and its context (social, religious, economic and geographic background), building materials used, building types (temples, forts) and town planning (Babylonia); Egyptian architecture and its context, major building types – temples (cult and mortuary), tombs (mastabas and pyramids), influences of natural elements in built form; Greek architecture and its context, major building types – temples (their nomenclature as per the arrangement of columns), public buildings; Roman architecture and its context, major building types – temples (Pantheon) and public buildings, innovation in building materials and structural systems and their usage; Early Christian and Romanesque architecture and its context, influence of Roman architecture and its manifestation, building types (churches) and their different interpretations across Europe; Byzantine architecture and its context, major building types (churches), innovation in structural system (pendentives) and space planning; Gothic architecture and its context – the evolution of architectural forms and influences; Renaissance architecture and its context – revival of classical architecture, influences in arts and architecture, phases of Renaissance architecture and its context, new structural systems (ribbed dome, lantern dome); Baroque and Rococo architecture and its interpretations across Europe and their colonies.

Essential Reading:

1. Sir Banister Fletcher, ***A History of Architecture***, Ed. Dan Cruickshank, 20th Edition, CBS Publishers and Distributors Pvt. Ltd., New Delhi

Supplementary Reading:

1. D. K. Ching, ***Architecture Form Space and Order***, 3rd Edition, Wiley

Semester: 2

PA 112	Architectural Design – II	2 Credits (0-0-3)

Pre-requisites: NIL

Transformation of forms to built spaces and incorporation of concepts of anthropometry and ergonomics; application of principles of design to design simple building elements (e.g. grills, windows, doors); taxonomy of spaces through classification of activities; appraisal of design requirements based on climatic factors, behavioural inputs, safety and security aspects and aesthetic criteria
Typical assignments – guard room/ bus stand/public toilet/small specialized shop (florists/cafe)

Essential Reading:

1. C. D. Joseph and Callender John, ***Time Saver Standards for Building Types,*** TMH Education
2. C. D. Joseph and Callender John, ***Time Saver Standards for Architectural Design Data,*** TMH Education

Supplementary Reading:

1. Neufert's, ***Architect's Data***, Blackwell Publishers

PA 122	Architectural Graphics –II	2 Credits (0-0-3)

Pre-requisites: Architectural Graphics – I

Projection of solids; section of solids – true shape of section using auxiliary planes; intersection of solid objects; surface development (preparation of physical models using surface development); axonometric projection; isometric projection

Essential Reading:

L. Warren J., D. Jon M., ***Fundamentals of Engineering Drawing – with an introduction to interactive computer graphics for design and production***, Prentice Hall

Supplementary Reading:

N. D. Bhatt, ***Engineering Drawing,*** Charotar Publishing House Pvt. Ltd.

PA 132	Building Construction - I	3 Credits (3-0-0)

Pre-requisites: NIL

Introduction to various building components from foundation to roof and their function; introduction to load transmission in load bearing & framed structures, their advantages, disadvantages and suitability; various types of load bearing and framed structures, their advantages, disadvantages and suitability; brick construction – types of brick, their dimensions and definitions, types of bonds in brickwork, foundations, plasters, buttresses, arches and lintels; stone construction – types of walls, bonds, arches and lintels; foundation – functions of foundations, types of foundations, simple load bearing foundations in brick and stone; concrete blocks – hollow and solid, stabilised mud blocks; timber work- simple carpentry joineries, different types of doors and windows, fixing details of frame, style, rail, panel, glazing including fixtures and fastenings

Essential Reading:

1. W.B. Mackay, ***Building Construction - Metric Volume-1***, Pearson
2. W.B. Mackay, ***Building Construction - Metric Volume-2***, Pearson

Supplementary Reading:

1. R. Chudley, ***Construction Technology, 5th Edition,*** Pearson Publication Oxford Heinemann
2. S. Emmitt and C. A. Gorse, ***Barry's Introduction to Construction of Buildings,*** Wiley
3. B. C. Punmia, ***Building Construction,*** Laxmi Publication Ltd.

PA 134	**Building Construction Studio - I**	**2 Credits (0-0-3)**

Pre-requisites: Building Construction - I

Preparation of drawings on following –

Brick construction – types of brick, their dimensions and definitions, types of bonds in brickwork, foundations, plasters, buttresses, arches and lintels; stone construction – types of walls, bonds, arches and lintels; foundation – functions of foundations, types of foundations, simple load bearing foundations in brick and stone; concrete blocks – hollow and solid, stabilised mud blocks; timber work- simple carpentry joineries, different types of doors and windows, fixing details of frame, style, rail, panel, glazing including fixtures and fastenings

Essential Reading:

1. W.B. Mackay, ***Building Construction - Metric Volume-1***, Pearson
2. W.B. Mackay, ***Building Construction - Metric Volume-2***, Pearson

Supplementary Reading:

1. R. Chudley, ***Construction Technology, 5th Edition,*** Pearson Publication Oxford Heinemann
2. S. Emmitt and C. A. Gorse, ***Barry's Introduction to Construction of Buildings,*** Wiley
3. B. C. Punmia, ***Building Construction,*** Laxmi Publication Ltd.

PA 142	**Building Materials – I**	**3 Credits (3-0-0)**

Pre-requisites: NIL

Brick - composition, sizes, properties and classification of bricks, tests for bricks; introduction of brickworks: masonry bonding & ornamental bonding, substitutes for bricks; stones - classification of stones; common building stones used in India; characteristics and use of stones; dressing of stone; artificial stones; introduction to stonework: rubble and ashlars masonry; metals- pig iron, cast iron, wrought iron – types, properties, steel – properties, types, market form of steel and uses of steel in construction, properties of mild steel and hard steel, defects in steel; timber - qualities of timber for construction; seasoning, storage and preservation of timber; use of different types wood in various parts of building; industrial timber: veneers, plywood, fibreboard, etc; lime - classification of lime. fat and hydraulic lime – properties and use; cement: composition of ordinary cement; function of cementing ingredients; properties of cement – fineness, soundness, setting times, etc; grades of cement and different types of cements used in construction; storage of cement in site; sand - sources of sand, classification, test of sand; grades of sand and their uses; mortar - types of mortar – lime mortar, mud mortar, lime-surkhi mortar, cement mortar; different grades of mortar, their compositions and properties; preparation of cement mortar; use and selection of mortar for different construction work; concrete - compositions and grades of concrete; various steps in concrete construction – batching, mixing, transporting, compacting, curing, shuttering, jointing. tests and quality control of concrete; design mix of concrete.

Essential Reading:

1. S. K. Duggal, ***Building Materials***, New Age International

Supplementary Reading:

1. Bindra & Arora, ***The Textbook of Building Construction***, Dhanpat Rai Publications
2. W.B. Mckay, ***Building Construction: Metric Vol. 1-2-3***, Pearson

PA 162	**Visual Arts – I**	**3 Credits (0-1-3)**

Pre-requisites: NIL

Sketching and free hand drawing (line, form, texture, scale, proportion); study of light and shade pattern; two dimensional and three dimensional compositions; rendering techniques (pencil, pen and ink, water colour, mixed media); graphic design (interpretation of different emotions/activities/ideas through visual or graphic representation); Introduction to visual cognition, psychological responses to art and art appreciation.

Essential Reading:

1. R. G. Gill, ***Rendering with pen and ink***, Thames and Hudson Ltd.
2. Wucius Wong, ***Principles of three Dimensional Design,*** John Wiley and Sons Inc.

Supplementary Reading:

1. Wucius Wong, ***Principles of Form and Design,*** John Wiley and Sons Inc.
2. Wucius Wong, ***Principles of Two Dimensional Design,*** John Wiley and Sons Inc.
3. Wucius Wong, ***Principles of Color Deisgn: Designing with Electronic Color,*** John Wiley and Sons Inc.

PA 172	History of Architecture – II	3 Credits (3-0-0)

Pre-requisites: NIL

Prehistoric architecture – Indus valley civilization and its context (social, religious, economic and geographic background), building materials and construction techniques adopted, town planning principles, later Vedic settlements; Buddhist architecture and its context, rock cut architecture and building types and other architectural features (rock cut caves, stupas, viharas ,chaityas etc); Hindu temple architecture and its key elements, evolution of temple form, classification of Hindu temples – North Indian temple architecture (Nagara architecture of Khajuraho temples, Orissan temple architecture, Māru-Gurjara temple architecture of Gujarat), Dravidian architecture of Pallavas, Cholas, Chalukyas, Pandyas, Madura and Vijaynagar dynasties; Indo-Islamic architecture and its context, major building types (tombs and mosques) and their structural systems (vaults, domes, pendentives etc) and architectural features (jaalis, surface articulation using stones, metal and wood), site planning and landscape features, classification of Indo-Islamic architecture of Sultanate period (Slave, Tughlaq and Lodhi) and Mughal period (Babar, Humayun, Akbar, Jahangir and Shah Jahan)

Essential Reading:

1. Percy Brown, ***Indian Architecture (Buddhist Hindu) Vol. I,*** Taraporevala and Sons
2. Percy Brown, ***Indian Architecture (Islamic Period) Vol. II***, Taraporevala and Sons, Bombay

Supplementary Reading:

1. J. A. Fergusson, ***A history of Indian and Eastern Architecture (Vol. I and II)***, Cambridge University Press, London

PA 182	Field Study - I	2 Credits (0-0-0)

Pre-requisites: NIL

Field study tour of historical buildings with emphasis on measured drawing; report submission on historical buildings visited with detailed presentation and model of measured drawing exercise

Essential Reading:

As per tour plan

Supplementary Reading:

As per tour plan

Semester: 3

PA 211	Architectural Design – III	4 Credits (0-0-6)

Pre-requisites: NIL

Introduction of design methodology – area programming, site analysis (using various attributes like climatic conditions, site constraints like privacy, noise, visual connectivity etc), site zoning, bubble diagram, proximity analysis;

Typical assignments – Residence design for a given professional (students would be expected to frame the requirements based on user profile); primary school/guest house; time problem (memorial with landscaping/creche)

Essential Reading:

1. C. D. Joseph and Callender John, ***Time Saver Standards for Building Types,*** TMH Education
2. C. D. Joseph and Callender John, ***Time Saver Standards for Architectural Design Data,*** TMH Education

Supplementary Reading:

1. Neufert's, ***Architect's Data***, Blackwell Publishers

PA 221	Architectural Graphics – III	2 Credits (0-0-3)

Pre-requisites: NIL

Perspective views of simple and complex geometrical forms (one point, multi-point perspective); views of buildings and objects from different viewing angles; sciography of geometrical and architectural objects – shades and shadows on the surfaces; using the concepts of perspective and sciography to draw internal and external architectural spaces

Essential Reading:

1. R. W. Gill, ***Perspective – From Basic to Creative***, Thames and Hudson Ltd.
2. E. L. Koller***,Light, Shade and Shadow,*** Dover Publications

Supplementary Reading:

1. Barrington Barber, ***Essential Guide to Drawing: Perspective and Composition,*** Arcturus Publishing Ltd.

PA 231 — Building Construction – II — 3 Credits (3-0-0)

Pre-requisites: NIL

Roof trusses - timber and steel trusses, types, fixing details showing purlin, rafter, tie, strut, cleat etc. different types of roof coverings: for flat and sloped roof with fixing details; timber floors - general idea of timber floors in relation to span, load transmission, Jack arch and composite floors; requirements of staircase, types of staircases, construction methods of – masonry staircase, timber staircase, RCC staircase, steel staircase and composite staircase; study of fire escape staircase; study of principles and methods of construction of RCC foundations and columns, types of foundations – raft foundations, grillage foundations and combination; pile foundation – precast piles, cast-in-situ piles, types of piles, method of driving piles, pile caps etc.,

Essential Reading:

1. W.B. Mckay, ***Building Construction: Metric Vol. 1-2-3***, Pearson

Supplementary Reading:

1. R. Chudley, ***Construction Technology, 5th Edition,*** Pearson Publication Oxford Heinemann
2. S. Emmitt and C. A. Gorse, ***Barry's Introduction to Construction of Buildings,*** Wiley
3. B. C. Punmia, ***Building Construction,*** Laxmi Publication Ltd.

PA 233 — Building Construction Studio – II — 2 Credits (0-0-3)

Pre-requisites: Building Construction - II

Preparation of drawings and plates on followings –

Roof trusses - timber and steel trusses, types, fixing details showing purlin, rafter, tie, strut, cleat etc. Different types of roof coverings: for flat and sloped roof with fixing details; timber floors - general idea of timber floors in relation to span, load transmission, Jack arch and composite floors; requirements of staircase, types of staircases, construction methods of – masonry staircase, timber staircase, RCC staircase, steel staircase and composite staircase, study of fire escape staircase; study of principles and methods of construction of RCC foundations and columns, types of foundations – Raft foundations, Grillage foundations and combination; pile foundation – precast piles, cast-in-situ piles, types of piles, method of driving piles, pile caps etc; typical section through a load bearing wall showing foundation, plinth, window or door sill, lintel with chajja, roof slab, cornice and parapet details etc.

Essential Reading:

1. W.B. Mckay, ***Building Construction: Metric Vol. 1-2-3***, Pearson

Supplementary Reading:

1. R. Chudley, ***Construction Technology, 5th Edition,*** Pearson Publication Oxford Heinemann

2. S. Emmitt and C. A. Gorse, ***Barry's Introduction to Construction of Buildings,*** Wiley
3. B. C. Punmia, ***Building Construction,*** Laxmi Publication Ltd.

PA 241	**Building Materials – II**	**3 Credits (3-0-0)**

Pre-requisites: NIL

Non Ferrous Metal- Aluminium, Copper, & important alloys like brass, bronze, etc – brief description of uses, corrosion of both ferrous and nonferrous metals – types and preventive measures; clay products - tiles, their properties and use - terra-cotta, earthenware, stoneware, porcelain, vitreous; special concrete - water repellent, waterproofing compounds, accelerators, air entraining agents, hardeners, plasticizer, Fly ash, their availability and uses, light weight concrete, ready-mix concrete, and precast concrete; wall & floor tiles - general character and construction process of traditional flooring like: IPS flooring, terrazzo flooring, sizes, classification & properties of tiles used in wall and flooring, selection criteria & methods of fixing various types of tiles; varnishes, paints, distempers- characteristics and process of varnishing, type and compositions of paints, types of painting system: aluminium paints, cement-based paints, oil emulsion paints, enamel paints, their selection criteria; plastics and polymers - types and use of plastic in building construction, properties of plastic; use of various polymer materials in building industry, use of nano-paints; miscellaneous materials - glass, fibre glass, cork, rubber, gypsum, sealants, asbestos, heat and sound insulating materials, their trade name and uses.

Essential Reading:

1. S. K. Duggal, ***Building Materials***, New Age International

Supplementary Reading:

1. Bindra & Arora, ***The Textbook of Building Construction***, Dhanpat Rai Publications
2. W.B. Mckay, ***Building Construction: Metric Vol. 1-2-3***, Pearson
3. Arthur Lyons, ***Materials for Architects and Builders – An Introduction***, Arnold, London

PA 261	**Visual Arts – II**	**3 Credits (0-1-3)**

Pre-requisites: NIL

Exposure to life and works for famous artists, art forms and movements; photography exercises – still photography (introduction to the concepts of lens types, framing, aperture, depth of field, focus, exposure, light conditions, introduction to architectural photography); basic of movie making; exercises on some common mediums used in visual arts – posters, comics, graffiti, murals, collage, glass painting

Essential Reading:

1. G. Berryman***, Notes on Graphic Design and Visual Communication,*** Crisp Learning Pub.

2. Keith P. F. Moxey, Moxey Keith, ***Art History, Aesthetics, Visual Studies***, Clark Art Institute

Supplementary Reading:

1. H. Honour, J. Fleming***, A World History of Art,*** Laurence King Pub.
2. Clark Studies in Visual Arts, ***The Meaning of Photography***, Yale Univ. Press
3. Harrison, ***Philosophy and the Visual Arts: Seeing and Abstracting***, Springer

PA 271	History of Architecture – III	3 Credits (3-0-0)

Pre-requisites: NIL

Industrial revolution and its manifestation in architecture (in reference to manufacturing of steel and use of Ferro-concrete), Great Exhibitions; New Art and Architecture and its context (works of Victor Horta); Chicago School of architecture (H.H Richardson, Louis Sullivan); Prairie style and Organic Architecture of F.L Wright; Responses to mechanisation – Deutscher Werkbund and Futurism; De Stijl and Amsterdam School; Functionalism in architecture - Bauhaus Style and Le Corbusier, International Style (Mies Van der Rohe, Philip Johnson, Louis Kahn), 20th century World Architecture of Japan, China, Scandinavian countries and Latin America (Eero Saarinen, Alvar Aalto, Oscar Niemeyer, Richard Neutra, Norman Foster, Antonio Gaudi, Frank O. Gehry, I. M. Pei, Kenzo Tange); Introduction to Postmodern Architecture

Essential Reading:

1. Kenneth Frampton, ***Modern Architecture***, 4th Edition, Thames and Hudson Ltd.

Supplementary Reading:

1. Siegfried Giedion, ***Space, Time and Architecture: The Growth of a New Tradition***, 5th Edition, Harvard University Press

PA 281	Climate Responsive Architecture	3 Credits (3-0-0)

Pre-requisites: NIL

Introduction - climate and weather, elements of climate, classification of tropical climates, climate balanced architecture; Bio-climatic approach - human comfort, thermal comfort factors, bioclimatic requirements, relation of climatic elements to comfort, the Bio-Climatic chart; environment and building forms - impact of external forces on building, site & building design, site selection, site planning, building orientation and placement, effect of landscaping; sun & building design - basic principles of heat transfer, day-lighting, solar control, thermal insulation; wind & building design-wind effect and air flow pattern, ventilation techniques, air movement around the buildings, stack effect and thermally induced air currents; architectural application - shelter for warm-humid climates, shelter for hot-dry climates, shelter for composite climate

Essential Reading:

1. O.H. Koenigsberger and others, ***Manual of Tropical Housing and Building – Part I – Climatic Design***, Longmans

Supplementary Reading:

1. Carl-eric Hagentoft, ***An Introduction to Building Physics***, Professional Pub. Service
2. M. Evans, ***Housing Climate & Comfort***, Architectural Press, London
3. B. Givoni, ***Man, Climate and Architecture***, Applied Science, Banking Essex
4. Donald Watson and Kenneth Labs, ***Climatic Design,*** McGraw Hill Book Company, New York

PA 283	Non-graphic Computer Application	2 Credits (0-0-3)

Pre-requisites: NIL

Microsoft Word - formatting, paragraph, table of contents, footnote, citation, caption, table of figures, page setup; Microsoft Excel - formula, formatting, conditional formatting, sort & filter, page layout; Microsoft PowerPoint - design of slide, slide transition, drawing objects, animation

Essential Reading:

1. Ron Mansfield, ***Working in Microsoft Office***, Tata McGRAW HILL

Supplementary Reading:

1. Vermaat, Shelly, ***Microsoft Office 2013 Advanced***, Cashman Series

Semester: 4

PA 212	Architectural Design – IV	4 Credits (0-0-6)

Pre-requisites: NIL

Design theory and their application; application of climatic data, social and structural considerations in more complex design problems such as community centre, students' dormitory, secondary school etc; analysis of a given design (landmarks in architecture and buildings in India); design emphasizing forms.
Typical assignments – design of a resort/small hotel based on field study; community centre; secondary school; time problem (temporary exhibition/ neighbourhood level commercial complex)

Essential Reading:

1. C. D. Joseph and Callender John, ***Time Saver Standards for Building Types,*** TMH Education
2. C. D. Joseph and Callender John, ***Time Saver Standards for Architectural Design Data,*** TMH Education

Supplementary Reading:

1. Neufert's, ***Architect's Data***, Blackwell Publishers

PA 222	Computer aided Design & Simulation – I	2 Credits (0-0-3)

Pre-requisites: NIL

AutoCAD 2D Basic- Drawing tools, modifying tools, array, working in layers, line type, line thickness, line type scale, colouring, hatching, block making, annotation, dimensioning; AutoCAD 2D Advanced- Viewports, UCS icon, Paper space& model space, sheet layout, micros, customized interface, customized line-type, customized hatch pattern; Digitization of hand drafted sheets of previous semester; AutoCAD 3D Basic- Basic objects, extrude, sweep, revolve, changing UCS, working in various views; AutoCAD 3D Advanced- Materials, Lights, Sun, Rendering; Developing of 3D models in AutoCAD of previous semester design project

Essential Reading:

1. George Omura, ***Mastering AutoCAD 2014 and AutoCAD LT 2014,*** Wiley

Supplementary Reading:

1. Ghassan Aouad, Song Wu, Angela Lee, Timothy Onyenobi, ***Computer Aided Design Guide for Architecture, Engineering and Construction***, Taylor and Francis

PA 232 Building Construction – III 3 Credits (3-0-0)

Pre-requisites: Building Construction – II

Study of principles and methods of construction of RCC, beams including cantilever beams, columns, one way, two way slabs-cantilever slabs, sloping RCC roof, vaults, domes including form-work techniques and reinforcement details; expansion joints - construction details at foundation, walls, floors and roof level for both concrete and brick work, water proofing at flat roof and damp proofing at basement; flooring – in mud, murrum, stones – marble, granite, tandur/kota stone, mosaic, terrazzo, ceramic tiles and wooden flooring; paving – cast in situ concrete, concrete tiles, interlocking blocks, clay tiles, brick and stone; plaster – method of plastering –
a) Internal (use of various finishes viz., lime, cement, plaster of Paris, puffing etc
b) External – smooth, rough, textured, grit plaster
Aluminium composite panel cladding; mild steel and aluminium doors and windows and partitions-wooden/steel/aluminium sliding and folding doors and partitions, steel doors for garages and workshops, collapsible gate and rolling shutters, remote control systems of doors and gates, fixing details of steel and aluminium sections at jamb, sill, head / lintel, details of mullion and transom including hardware details; structural glazing, PVC & FRP, frameless glass doors and windows and partitions; fire resistive construction for different components of a building; introduction to Cost Effective Construction Technologies (CECT) in building construction - stub foundation (foundation), rat – trap bond (walls), brick arches (at lintel level), filler Slab (roof), use of ferro-cement

Essential Reading:

1. W.B. Mckay, ***Building Construction: Metric Vol. 1-2-3***, Pearson

Supplementary Reading:

1. R. Chudley, ***Construction Technology, 5th Edition,*** Pearson Publication Oxford Heinemann
2. S. Emmitt and C. A. Gorse, ***Barry's Introduction to Construction of Buildings,*** Wiley
3. B. C. Punmia, ***Building Construction,*** Laxmi Publication Ltd.

PA 234 Building Construction Studio – III 2 Credits (0-0-3)

Pre-requisites: Building Construction Studio - II

Preparation of drawings and plates on followings –

Methods of construction of RCC, beams including cantilever beams, columns, one way, two way slabs-cantilever slabs, sloping RCC roof, vaults, domes including form-work techniques and reinforcement details; expansion joints - construction details at foundation, walls, floors and roof level for both concrete and brick work, water proofing at flat roof and damp proofing at basement; flooring – in mud, murrum, stones – marble, granite, tandur/kota stone, mosaic, terrazzo, ceramic tiles and wooden flooring; paving – cast in situ concrete, concrete tiles, interlocking blocks, clay tiles, brick and stone; plaster – method of plastering
a) Internal (use of various finishes viz., lime, cement, plaster of Paris, puffing etc.
b) External – smooth, rough, textured, grit plaster;
Aluminium composite panel cladding; mild steel and aluminium doors and windows and partitions-wooden/steel/aluminium sliding and folding doors and partitions, steel doors for garages and

workshops, collapsible gate and rolling shutters, remote control systems of doors and gates, fixing details of steel and aluminium sections at jamb, sill, head / lintel, details of mullion and transom including hardware details; structural glazing, PVC & FRP, frameless glass doors and windows and partitions; fire resistive construction for different components of a building; Cost Effective Construction Technologies (CECT) in building construction - stub Foundation (foundation), rat – trap bond (walls), brick arches (at lintel level), filler slab (roof), use of ferro cement

Essential Reading:

1. W.B. Mckay, ***Building Construction: Metric Vol. 1-2-3***, Pearson

Supplementary Reading:

1. R. Chudley, ***Construction Technology, 5th Edition,*** Pearson Publication Oxford Heinemann
2. S. Emmitt and C. A. Gorse, ***Barry's Introduction to Construction of Buildings,*** Wiley
3. B. C. Punmia, ***Building Construction,*** Laxmi Publication Ltd.

PA 272 History of Architecture – IV 3 Credits (3-0-0)

Pre-requisites: NIL

Architecture post industrial revolution in India; Colonialism and its manifestation on architecture in India – British, Portuguese, French, Danish; architecture of nationalism, regionalism and revivalism in India; Modernism in India with reference to International styles (Baroque, Neo-classical and Art Deco, etc) and Indo-Saracenic architecture with their context; industrial functionalism; architecture after independence in India; Modern architecture in India after independence and its context (1947 – 1990); architecture post liberalisation in India (1990 onwards)

Essential Reading:

1. Jon Lang, M. Desai, ***Architecture and Independence: Search for Identity - India, 1880 to 1980***, Oxford University Press
2. R. Mehrotra, ***Architecture in India since 1990***, Pictor Publishing Pvt. Ltd.

Supplementary Reading:

1. Jon Lang, ***A Concise History of Modern Architecture in India***, Permanent Black Publishers

PA 282 Building Bye Laws and Codes of Practices 3 Credits (3-0-0)

Pre-requisites: NIL

Introduction to professional practice, codes, ethics and guidelines for professional fees and charges; exposure to skills and techniques of handling and management of a particular project; acquaintance to the concepts of project management, contractual obligations and legal practices; study development control guidelines, municipal byelaws, IS codes of practice pertinent to design , drawing and procedure for submission to regulatory bodies; guidelines and regulations pertaining to fire prevention, safety measures and other ancillary services

Essential Reading:

1. BIS, **National Building Code**, 2005,

Supplementary Reading:

PA 284	**Model Making Workshop**	**2 Credits (0-0-3)**

Pre-requisites: NIL

Making of three dimensional forms such as cubes, pyramids, cones etc. using different types of materials such as paper, card board, mount board, balsa wood, wax, plaster of Paris etc; joints – different types of joints, joinery details (which are commonly used in timber construction and interiors); application of veneers/laminates on different types of timber surfaces i.e., teak and commercial woods viz. ply, block boards, particle boards, engraving and carving, polishing and painting, clay work, brick, cob, wattle and daub, rammed earth; masonry construction – walls, arches and corbel; marking of geometrical forms on the ground; wall painting, sculpture making exercises

Essential Reading:

NA

Supplementary Reading:

PA 286	**Field Study - II**	**2 Credits (0-0-0)**

Pre-requisites: NIL

Field study tour for historical and modern buildings; selection of site and study of its features for design assignment (V^{th} semester); report submission on the critical appraisal of relevant contemporary buildings visited during field study

Essential Reading:

As per tour plan

Supplementary Reading:

As per tour plan

Semester: 5

PA 311	Architectural Design - V	6 Credits (0-0-9)

Pre-requisites: NIL

Formulation of design criterions and socio-economic information, climatic data, structural considerations and behavioural aspects; design of medium/high rise buildings with complex functional relationship and intricate structural and building services

Typical assignments – Motel/ museum/office building (based on field study in previous semester); health centre; mixed use development – multi-storied residential development with commercial space; time problem (club house/small library)

Essential Reading:

1. C. D. Joseph and Callender John, ***Time Saver Standards for Building Types,*** TMH Education
2. C. D. Joseph and Callender John, ***Time Saver Standards for Architectural Design Data,*** TMH Education

Supplementary Reading:

1. Neufert's, ***Architect's Data***, Blackwell Publishers

PA 321	Computer Aided Design and Simulation-II	2 Credits (0-0-3)

Pre-requisites: NIL

Autodesk Revit Architecture - Introduction to interface, working in Revit, schedule, sheets, family creation, rendering, walkthrough; 3Ds Max Design- Basic commands of 3Ds Max, import of 3D model from CAD environment, material, light, rendering, walkthrough, animation; Google Sketch Up- Basic drafting, materials, rendering; Photoshop - Basic commands, image editing in Photoshop, sheet rendering in Photoshop; Corel Draw - Basic commands, sheet composition in Corel Draw

Essential Reading:

1. James Vandezande, Eddy Krygiel, Phil Read, ***Mastering Autodesk Revit Architecture 2014,*** Wiley India

Supplementary Reading:

1. Daniel John Stine, ***Commercial Design Using Autodesk Revit Architecture 2013***, SDC Publication

PA 331	Working Drawing - I	2 Credits (0-0-3)

Pre-requisites: Building Construction Studio (I/II/III)

Introduction to the concept of professional working drawing practices; detail construction drawing as per contract documents with proper dimensioning and labelling; the residential design assignment in IIIrd semester Architectural Design to be utilized for this assignment

Layout plan of a residential building showing details of internal roads, services, excavation plan, foundation plan, details of internal finishes of all the floors, terrace plan showing roof drainage, elevations of the building showing all details on the external surface (with labels), minimum two sections through toilets and staircases and also showing any level differences and an additional skin section showing details, door window schedule

Essential Reading:

1. C. D. Joseph and Callender John, ***Time Saver Standards for Building Types,*** TMH Education

Supplementary Reading:

PA 351	Building Services – I	3 Credits (3-0-0)

Pre-requisites: NIL

Water Supply - sources of water supply, standards of purity and treatment of water, qualities of potable water, domestic water demand, capacity of over head tanks and calculation of water consumption; domestic water piping systems - water distribution networks, cold and hot water distribution within the building, specifications and sketches of various plumbing fittings for buildings, uses of valves, taps, and their different types, house/service connection, layout of water supply lines in a domestic house; sanitation - basic principles of sanitation and disposal of waste matter from building, brief description of various systems of sewage disposal and their principles, details of a septic tank and capacity calculation; sewer system - quantity of sewage and storm water, infiltration, runoff calculation, Manning's formulae, partial flow diagram, design of sewers, shapes of sewers, factors affecting the design of sewers, materials, bend , pipe joints used in sewer systems; sewer appurtenances - manholes, sub drains, culverts, ditches and gutters, drop inlets and catch basins roads and pavements, storm overflow/regulators, intercepting chambers, inspection chambers and their proper location and ventilation of sewers, laying and testing of sewer, gradient used in laying of drains and sewers, and respective sizes; sewage treatment - the process of self purification, disposal of sewage from isolated building (septic tank, Imhoff tank), sewage breakdown, plumbing definitions and related terms, plumbing systems (one pipe, two pipe; etc), house drainage system and sanitary appliances and traps; design considerations on drainage scheme - preparation of plan, planning of bathrooms, lavatory blocks and kitchen in domestic and multi-storeyed buildings, Indian standards for sanitary convenience, model bye laws regarding sanitation of buildings

Essential Reading:

1. S.C. Rangwala, ***Water Supply and Sanitary Engineering***, Charter Publishing House, Anand
2. G. S. Birdie, ***Water Supply and Sanitary Engineering***, Dhanpat Rai & Sons.

Supplementary Reading:

1. B. C. Punmia, ***Water Supply Engineering***, Laxmi Publication, New Delhi
2. S. K. Garg, ***Water Supply Engineering,*** Khanna Publishers

Semester: 6

PA 312	Architectural Design - VI	6 Credits (0-0-9)

Pre-requisites: NIL

Site planning exercises incorporating climatology, solar architecture, landscaping, environmental behaviour; assignments to incorporate higher level of intricacies in terms of regulations, building services, structural engineering, building materials and detail;
Typical assignments – hospitals; star hotels; cultural centres with auditorium; shopping malls with multiplex; time problem (site planning exercise – layout of amusement park)

Essential Reading:

1. D. Joseph and Callender John, ***Time Saver Standards for Building Types,*** TMH Education
2. D. Joseph and Callender John, ***Time Saver Standards for Architectural Design Data,*** TMH Education

Supplementary Reading:

1. Neufert's, ***Architect's Data***, Blackwell Publishers

PA 322	Computer Aided Design and Simulation-III	2 Credits (0-0-3)

Pre-requisites: NIL

Ecotect Analysis - Study of weather file, Simulation of small design project of previous semester in Ecotect Analysis, Study of reports generated; Naviswork - Navigation, clash detective, timeliner, animator, presenter

Essential Reading:

1. Jason Dodds, Scott Johnson, ***Mastering Autodesk Navisworks 2013,*** Sybex
2. Chuck Eastman, Paul Teicholz, Rafael Sacks and Kathleen Liston, ***BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors***, by John Wiley and Sons

Supplementary Reading:

1. Deepak Maini, ***Up and Running with Autodesk Navisworks 2014***, Createspace

PA 332	Working Drawing – II	4 Credits (0-0-6)

Pre-requisites: Working Drawing – I; Building Construction Studio

Building construction drawings to be prepared as per contract documents and following proper nomenclatures of dimensioning and labelling; in continuation to Working Drawing – I and the same design assignment used thereof

Details of toilets (plan, section, elevation, fixture/joinery details); details of kitchen (plan, section, elevation, fixture/joinery details); layout of plumbing and sanitary lines and their connection to septic tank/main service lines; designing and detailing of a septic tank with soak pit; electric layout of all floors with specification of fixtures; details of flooring and internal finishes; additional details e.g. carpentry details/ metal finish detail; municipal submission drawings

Essential Reading:

NA

Supplementary Reading:

PA 352	**Building Services – II**	**3 Credits (3-0-0)**

Pre-requisites: NIL

Refuse disposal - sources types collection, storage and transport, provisions for refuse disposal at individual building level, refuse chutes; solid waste treatment; storm water drainage - collection and disposal; electrical services - various wiring systems, calculation and distribution of load, electrical fittings and appliances, telephone and television services, detailed layout of electrical, telephone and television services in a residence; hot water supply in high rise building, boiler, furnaces, solar water heaters, computing special demands of water for swimming pools, air-conditioning plants, fire fighting, street washing, fountains and gardens etc, their schematic layout

Essential Reading:

1. S.C. Rangwala, ***Water Supply and Sanitary Engineering***, Charter Publishing House, Anand
2. G. S. Birdie, ***Water Supply and Sanitary Engineering***, Dhanpat Rai & Sons.

Supplementary Reading:

1. William. K. Y. Tao, ***Mechanical and electrical Systems in Buildings***, Pearsons

PA 382	**Theory of Design**	**4 Credits (3-1-0)**

Pre-requisites: NIL

Design process – design as a process, different school of thoughts and processes, philosophies and approaches to design and its methodology, KISS principles (Kelly Johnson), Use-centered design (John Flach and Cynthia Dominguez), User-centered design, challenges of designer; history of design; stages of design (divergence, transformation and convergence); systematic search (decision system approach, logical certainty); selection of strategies (linear, cyclic, branching, adaptive) and design methods

Essential Reading:

John Chris Jones***, Design Methods,*** Wiley

Supplementary Reading:

Kari Jormakka, ***Basic Design Methods***, 3rd Edition, Marston House Publishers

PA 384	**Human Settlement & Vernacular Architecture**	**3 Credits (3-0-0)**

Pre-requisites: NIL

Evolution of human settlement and pattern of early cities; industrial revolution and town planning concepts; different philosophies and ideas for designing cities; conservation and development of old city – concepts of regeneration, revitalization, redevelopment; participatory planning process

Introduction to vernacular architecture – definition, scope, context; building materials and construction techniques in traditional vernacular architecture; vernacular architecture in India (Rajasthan, Gujarat, Kerala, Bengal, North-Eastern hills of India); post-modern vernacular architecture

Essential Reading:

1. Peter Hall, ***Cities of Tomorrow – An Intellectual History of Urban Planning and Design in 20th century***, 2nd Edition, Wiley-Blackwell
2. Dawson and I. Cooper, ***Traditional Building of India***, Thames and Hudson Ltd.
3. L. Asquith, ***Vernacular Architecture in the 21st century***, Taylor and Francis

Supplementary Reading:

1. John May and Anthony Reid, ***Handmade Houses and Other Buildings – The World of Vernacular Architecture***, Thames and Hudson Ltd.
2. Arthur Gallion, ***Urban Pattern – City Planning and Design***, CBS Publishers

Semester: 7

PA 411	Architectural Design - VII	8 Credits (0-0-12)

Pre-requisites: NIL

Introduction of advanced site planning exercises (scale of urban design projects); computing design requirements and space programming based on climatic data, behavioural considerations, economic analyses; considerations of building services as well as higher order infrastructure services as required in site planning exercises (accessibility/drainage/sewerage/water supply/power etc)

Typical assignments – urban transport facilities; group housing; educational campus; stadium; CBD; time problem (any one not covered in class)

Essential Reading:

1. D. Joseph and Callender John, ***Time Saver Standards for Building Types,*** TMH Education
2. D. Joseph and Callender John, ***Time Saver Standards for Architectural Design Data,*** TMH Education

Supplementary Reading:

1. Neufert's, ***Architect's Data***, Blackwell Publishers

PA 431	Advanced Building Construction Studio	2 Credits (0-0-3)

Pre-requisites: NIL

Introduction to space structures, possibilities in different materials, types of space structures and possibilities in different materials to cover large spans; general study of shell structures and folded plate structures in concrete, their types, construction aspects, merits and demerits etc; general study of grid structures and skeletal structures, space frames, domes etc. in steel, their types, construction aspects, merits and demerits etc; precast concrete - design considerations and constraints, advantages over cast in situ construction, construction technique, joinery details and application; modular coordination, RCC fabricated roofing system to cover large span with or without north light, construction of basement in R.C.C; study of pre-stressed concrete, principles and methods of pre-stressing, systems of pre-stressing, advantages, disadvantages and applications; temporary structures - materials and techniques used, constructional aspects using timber and steel; general study of construction techniques to cover large spans using short length timber and laminated timber materials, lamella roofing, portal frames, solid beams and web beams; general study of suspension structures & catenary structures; membrane structures and pneumatic structures - types, materials used, merits, demerits and examples; high-rise building - foundation, structural systems and architectural design considerations; earthquakes and its effect on buildings, earthquake zones in India, architectural design considerations and constructional detailing for earthquake resistance.

Essential Reading:

1. Mitchell, ***Advanced Building Construction***,

Supplementary Reading:

1. M. Salvadorri, ***Structures in Architecture***,
2. L.S. Beedle, ***Advances in Tall Buildings***,
3. R. Barry, ***The Construction of Buildings, Vol.1-5***, Orient Longman Ltd.
4. Chudley, ***Construction Technology, Vol. 1-4***, British Library Cataloguing
5. M. S. Shetty, ***Concrete Technology***, S. Chand & Co.
6. ***Explanatory Handbook on Codes for Earthquake Engineering***, IS-1893-1975 & IS-4326-1976, Bureau of Indian Standards
7. Mohiuddin Ali Khan, ***Earthquake- Resistant Structures Design, Build, and Retrofit***, Elsevier B/H

PA 441	Advanced Building Materials	3 Credits (3-0-0)

Pre-requisites: NIL

Plastics- General properties of plastics, fillers and plasicizers, molding and fabricating methods for plastics, thermosetting plastics, thermoplastics resins, elastomers or synthetic rubbers, combination of plastic and other materials; Metals- Steel and steel alloy, aluminium and aluminium based alloys, copper and copper-based alloys, Lead and lead-based alloys, nickel and nickel-based alloys; Synthetic boards; Porcelain-enameled products; Asphalt and bituminous products; Composite panels

Essential Reading:

1. Frederick S. Merritt and Jonathan T. Ricketts, ***Building Design and Construction Handbook***, McGraw Hill

Supplementary Reading:

1. Stephan Engelsmann, Valerie Spalding and Stefan Peters, ***Plastics in Architecture and Construction,*** Birkh User Architecture

PA 451	Advanced Building Services	2 Credits (0-0-3)

Pre-requisites: NIL

Mechanical ventilation - study of Air Conditioning systems and their applicability, components of AC’s systems such as chilling plants, cooling towers, air handling units, calculation of AC loads, air distribution systems, ducts and ducting layouts; vertical transportation - study of elevators, various components of elevators, standard space requirements, various types of elevators and architectural implications, study of escalators, their components, arrangements and functioning, space requirement, construction detailing; fire safety- Introduction to fire safety in building, causes of fire in buildings, types of fire, spread of fire, production of smoke and poisonous gases, fire safety and preventive measures, fire fighting regulations with reference to National Building Code, fire escape, stairways and escape routes, dry and wet risers, water demand for fire fighting, storage tanks, fire hydrants, etc, study of fire detection systems, smoke detectors, heat detectors, fire alarms, fire fighting extinguishing systems, automatic sprinkler systems

Essential Reading:

1. P. N. Ananthanarayan, ***Basic Refrigeration and Air Conditioning***, TMH Pvt. Ltd.
2. Rodney R. Adler, ***Vertical Transportation for Buildings***, American Elsevier Pub. Co.

Supplementary Reading:

1. ***National Building Code***, 2005, BIS
2. ***Life Safety Code***, National Fire Protection Association, USA
3. D. Nield, ***Mitchell's Advanced Building Construction (Components, Services & Finishes)***, Allied Publishers
4. C. P. Arora, ***Refrigeration & Air conditioning***, TMH Education
5. F. Hall, ***Building Services and Equipments - Vol. I - II***, Longman Group Ltd.

Semester: 8

PA 412	Research Project – II (Thesis)	12 Credits (0-0-0)

Pre-requisites: NIL

Based on topic selected and dissertation in previous semester detail design proposal for the chosen project like cultural centre, educational campus, religious complex, industrial centre, recreational complex, civic centre, television studio, cinema studio, aquarium, zoological park, airport terminal, hotel or hospitals
Design proposal with construction and service details, interior layout. Presentation with complete rendered drawings, model and perspectives

Essential Reading:

As per thesis topic

Supplementary Reading:

As per thesis topic

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